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HEAT TREATING THE ALUMINUM ALLOYS

By **G. W. BIRDSALL,** *Reynolds Metals Company*
Louisville, Kentucky

COMBINATIONS of metals like those found in the aluminum alloys may have exceedingly complex structure. A molten aluminum alloy may be composed of six to nine different metals, some dissolved in others (like ink in water), and some not dissolved but just mixed in (like oil in water). As the molten alloy is allowed to cool, it will reach a point where solidification begins.

At this point, "crystals" begin to form. With continued cooling, additional crystals form, building up on the first ones, in turn producing "grains." So now the solidified metal is composed of grains, in turn composed of crystals.

In addition, certain compounds are formed by the various combinations of metals. These compounds may solidify out separately, either between the grains along the grain boundaries, or in the grains between the crystals. Too, certain other elements may separate out during cooling to room temperature. Obviously, the resulting structure is quite complex.

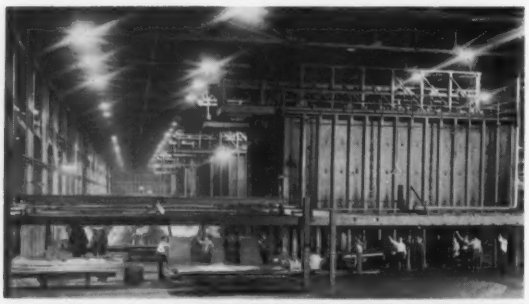


Fig. 1—Large elevated electric furnaces for heat treating aluminum sheets which are hung on edge from frames. Note loading and unloading areas alongside furnace.

The Time Element

It is important to understand the influence of time in heat treating metals. Most changes in the structure of a metal require a certain amount of time for completion.

Also time is required for the heat to soak thoroughly throughout all portions of the metal piece being treated. This is necessary in order that sufficient temperature rise be produced in all sections to provide the change in metallurgical structure desired. While a fast treatment in a furnace operated at a higher temperature might bring the interior of the work up to temperature quicker, it would be sure to heat the edges and corners of the work to excessive temperatures and probably damage those portions. For these reasons, allowance for proper time "at temperature" is essential in any heat treatment.

The time element enters into heat treatment in another important manner. Because a certain period of time is required for structural or metallurgical changes to reach a completed or stable stage, it is possible to quickly change the temperature of the metal and thereby obtain at room temperature certain desired types of structures that could not otherwise be had at room temperature.

To see how this works, let's start out with a pure metal for the sake of simplicity and see how the time element influences the structure. Chart 1 indicates the relation between time and temperature as a pure metal is allowed to cool from the molten state, represented by point "A." As its temperature falls, it reaches a point "B" where the metal begins to solidify or freeze. For pure aluminum, this freezing point is 1220.4°F.

Note that the curve indicates the temperature remains at this value for a period of time. This is because the change from a liquid to a solid is accompanied by the release of heat, the mechanism of the operation being such that just enough heat is released to balance that being lost, thus retaining the temperature of the metal constant during the period this solidification is taking place. So the curve is level from "B" to "C."

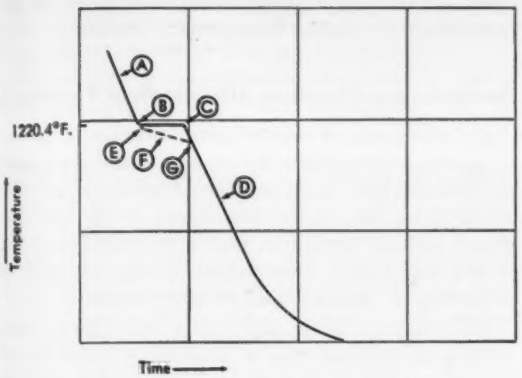
As soon as the metal has completely solidified, its temperature again falls gradually as it is allowed to cool, represented by the sloping line "D."

It should be noted that only a pure metal follows this type of curve . . . and each different metal has a different solidification or freezing point; that is, the level portion of the curve or "plateau" will come at a different temperature.

Now let's see what happens when we melt two pure metals together—let's say aluminum and copper—and allow them to cool. We find that we have a curve of an entirely different shape because the combination of the two metals has a freezing "range" instead of a freezing "point"; that is, the material begins to freeze at one temperature and continues to freeze while the temperature falls to a lower value before all of it has solidified. This is shown by the dotted portion of the curve at "F" in Chart 1 where the curve slopes from "E" to "G."

The combination of aluminum and copper does not freeze or solidify completely at a single temperature because the mixture formed by the two metals behaves in an entirely different manner than a pure metal like copper or aluminum (alone). Suppose we examine this freezing action for a moment, tracing the new curve on Chart 1.

Chart 1



Time versus Temperature for a pure metal.

Differential Freezing

At "E", Chart 1, the crystals forming out as the molten metal is just beginning to solidify will consist of an alloy of almost pure aluminum. As the temperature falls, crystals with appreciable amounts of copper will begin forming. With continued dropping temperature, the crystals forming will contain more and more copper. Thus at "E", the alloy particles freezing out may contain 99.9% aluminum, 0.1% copper. Just below "E", the particles freezing out of solution may contain 98% aluminum, 2% copper. Similarly, particles containing 97% aluminum, 3% copper will freeze out at a lower temperature, and so on.

Thus as the temperature falls, the material freezing out of solution at any particular moment corresponds to the alloy of aluminum and copper that freezes at that particular temperature.

This accounts for the fact that as the temperature curve traverses the "F" portion, Chart 1, the alloy particles or crystals forming out of the molten metal contain more and more copper. At "G", the entire mass becomes solidified and the temperature drops along the same type of curve as before.

When the molten metal contains more than two elements, this curve changes considerably and the freezing action becomes increasingly complicated. It is evident that in an aluminum alloy where we may have six to nine different elements, the action may be extremely complicated. Especially because the many different elements in turn form various mixtures or compounds which may behave in still different ways to further complicate the situation.

Precipitation

One of the complications that results from having these many different elements in the aluminum alloy is that certain combinations of elements may form mixtures or compounds which may freeze out of solution or separate out in small independent particles before or even after most of the other material has solidified.

These particles may be extremely small and may exist between the surfaces of adjoining crystals in such a manner as to "lock" the crystals by hindering them from sliding and thus increasing the resistance to mechanically working the material. This in turn may make the metal hard, tough, brittle, etc. Depending upon circumstances, the result may be desirable or undesirable.

This precipitation or separating out from the molten metal can be demonstrated in this manner: Place several spoonfuls of borax in a glass of boiling water, adding borax until no more will dissolve and some remains in the bottom of the glass even after repeated stirring. Pour this solution into another glass, leaving behind the extra borax. We now have a "saturated" solution of borax in water.

Then place this glass in a basin of cold water and stir the solution. As it cools, the temperature will drop to a point where the water can not hold all of the borax in solution. We now have a "supersaturated" solution in which the extra borax will immediately form borax crystals as it "precipitates" out of the solution.

Cooling

The same thing happens when a molten aluminum alloy is allowed to cool. Various elements and combinations of elements will precipitate out of the molten alloy as the temperature falls to a point where they can no longer be held in solution. Certain compounds may precipitate out after solidification.

When a constituent precipitates out, it may accumulate between grains along grain boundaries, or in the

Fig. 2—A 30,000-pound capacity McCann soaking furnace for handling billets in an extrusion plant. Note connections to thermocouples embedded at various points in the load for checking temperatures.

form of minute particles between crystals inside the grains. These particles may thus be present in the slip planes between adjacent crystals. If the same particle is partially imbedded in both surfaces of adjoining crystals, it is evident that it will tend to lock those surfaces together and prevent them from sliding freely one on the other. Thus such particles will tend to increase the resistance to slippage between crystals because of this "keying" effect.

Fig. 3—Lindberg multiple-zone heat-treating furnace for aluminum with quenching chamber and automatic control.

With slippage made more difficult, the metal acts like it had fewer slip planes, is harder to work and may be considerably stronger. So the end result may be that the mechanical properties of the metal are greatly improved. As we will see, this is the aim of certain heat-treating cycles.

During cooling, there are not only solids precipitating out of a liquid (the molten metal), but also solids precipitating out of solids. Just as a solid metal can diffuse into another metal (solid diffusion, detailed below), so can a solid precipitate out from another solid.

Solid Diffusion

While it is well known that some liquids readily dissolve certain solids, few people are familiar with the fact that certain solids can dissolve other solids. It is a fact, however, that if a gold block and a silver block are cleaned carefully and pressed tightly together, the dividing line will gradually disappear, one metal blending or dissolving into the other. While this action will occur at room temperature, it is greatly speeded by heating both metals.

In a similar manner, the copper is caused to diffuse throughout the metal structure by heating the metal to a temperature just under its melting point, followed by slow cooling. This treatment is known as "homogenizing." For many aluminum alloys it is done in the temperature range of 900-1000°F. By this means it is possible to overcome the tendency of certain constituents to segregate or separate to form thin and dense areas. Homogenizing thus is an aid in bringing about proper uniform distribution of the alloying elements and other constituents, and so helps in producing the desired homogeneous structure.

Strengthening Aluminum Alloys by Heat Treatment

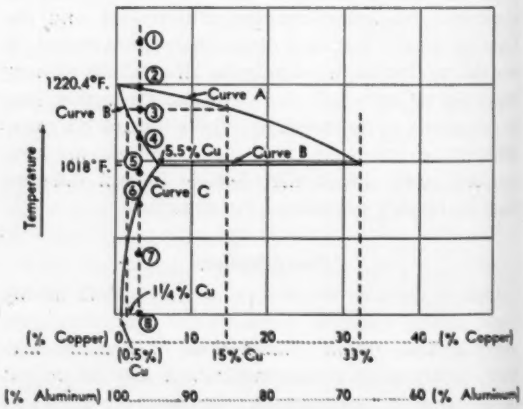
As was explained briefly under "precipitation," it is possible to strengthen the aluminum alloys by causing certain constituents to precipitate out inside the grains along the crystal boundaries or in the slip planes between crystals in such a manner as to lock or key the crystals, thus hindering slippage and so producing a "harder" and stronger material.

Also resistance to slippage can be increased by controlling the material that is precipitated between the crystals so that it acts like a "sharp grit" instead of like a "ball bearing." It is evident that a material that tends to aid free movement of one crystal on another will produce a softer, weaker alloy, whereas a precipitate that tends to prevent such movement will in turn produce a harder and stronger structure.

Let's examine Chart 2 to see why particular temperature ranges are required and to find out about the "aging" treatment—either natural or artificial—that is necessary to develop maximum strength in the aluminum alloys.

The vertical scale in Chart 2 represents temperature, starting with a low temperature at the bottom and going up above the melting point of the aluminum alloys. Since the alloys we are going to look at have aluminum and copper as the principal constituents, we can make the horizontal or base scale a double scale. Going from left to right, the upper scale measures per cent of copper from zero to 40%. Disregarding other constituents, we can say that remainder at any point is aluminum. So we can put in another scale immediately below the copper one reading 100-90-80-70-60% aluminum for the same points designated as 0-10-20-30-40% copper respectively.

Chart II



"Constitution" diagram for copper-aluminum alloys.

For our purpose, we have selected an alloy containing 3% copper at room temperature (97% aluminum), represented by Point 8 on the chart. Now let's see what happens when we heat and cool this alloy.

First the temperature of the material will be raised along the vertical dotted line to Point 1—say 1300°F. At this temperature all the material is molten and the copper has dissolved in the aluminum.

Now the material is allowed to cool to 1190°F—Point 2 lying on Curve A. This curve represents the temperature at which the molten metal starts to solidify. The first crystals that start to form here will be almost pure aluminum. These crystals will serve as the nuclei or center points around which the grains will form by solidification of other crystals on them as cooling continues.

Solid Solution

Now we will allow the material to cool to 1160°F—Point 3—and hold it at this temperature while we see what is happening here. Since solidification began at Point 2, the material is now partly solidified and partly molten. Because the aluminum has been crystallizing out of solution with very little copper, the copper content of the still molten material is increasing.

Since the information in the chart we are studying was obtained from tests upon a whole series of alloys with different compositions as indicated by the two horizontal scales, it is possible to tell exactly how much copper is contained in the aluminum-copper alloy that is solidifying out of solution and also to tell how much copper is in the still molten portion of the material. In fact, such diagrams are called "constitution" diagrams.

First we extend a horizontal dotted line left from Point 3 to Curve B (which represents the temperature at which freezing is completed—for the different compositions). Then from the point where we strike Curve B, we run a vertical line to the base. Here the copper scale tells us that the alloy that completes freezing out at 1160°F. contains about 1¼% copper. So now we know that at Point 3 the crystals forming contain 1¼% copper.

To find the copper content of the still molten portion, we run a horizontal line to the right from Point 3 to Curve A—the curve that indicates the beginning of freezing. Where this line strikes Curve A then tells the amount of copper in the alloy just beginning to freeze. By extending a vertical line from this point on Curve A to the base scale, we find that the molten material contains about 15% copper.

At lower temperatures (between Points 3 and 4), the crystals just forming will contain more and more copper. Likewise, the remaining molten material will also contain a greater percentage of copper. Thus as the temperature falls, the material freezing out of solution at any particular moment corresponds to the alloy of aluminum and copper that freezes at that particular temperature. This is "differential freezing".

Thus at any point between Curve A and Curve B, we have a mixture of solid particles and still molten liquid. The solid particles consist of aluminum with a certain amount of copper dissolved in them. When one metal remains dissolved in another like this, the combination is called a "solid solution".

Diffusion

At Point 4 all the material has solidified. By extending a horizontal line to the right to Curve A, we note that the very last crystals to solidify contained about 26% copper, while the very first crystals to solidify (at Point 2) contained practically pure aluminum. So at Point 4 we have grains whose center consists of almost pure aluminum crystals and whose extreme outer surface is formed of crystals having 26% copper. The entire copper content or average throughout the entire grain, however, is 3%, since we can have no more or no less than the 3% with which we started.

Fig. 4—Upton salt bath unit for heat treating small fabricated aluminum parts.

Now let's go somewhat below Curve B to say 1018°F.—Point 5—and hold the material at this temperature while we examine what is happening. At any position below Point 4, the material is a solid. But that does not mean that more changes do not occur.

To understand this last statement, we must go back to a fundamental. Any metal can exist in at least three different forms—vapor, liquid or solid. *In addition, many common metals appear in more than one solid form.* These are known as "phases".

The aluminum-copper alloys we are studying have four phases—a completely liquid phase in the chart above Curve A, a second phase consisting of solid particles in molten material in the area between Curve A and Curve B, a third phase in the area below Curve B and to the left of Curve C, where the material is a solid, and a fourth phase in the area below Curve B and to the right of Curve C where the material is also solid but in a different form as will be explained.

But let's get back to see what happens when we

(Continued on page 36)

COPPER BRAZING

By **THOMAS W. FERGUSON, JR.**, *General Manager*
J. W. Rex Company
Lansdale, Pennsylvania

COPPER brazing has long been known to the steel industry as a means of joining parts. Until a few years ago, the automotive and appliance industries had made up the larger percentage of the list of users of copper brazing because of their high productivity and specialized engineering staffs; but today, this efficient and inexpensive method of assembly can be accomplished on multiplicity of parts made of many different alloys in jobbing quantities with substantial savings.

The commercial heat treating industry has made great strides in recent years in the development of this process through practical experiments for usage in semi-production or jobbing production quantities. Many factors govern decisions in the proper use of copper brazing, and these factors must be thoroughly understood before use.

Process Description

Assemblies are put together by means of press fitting, staking, pinning, spotwelding, weld tacking, etc. Copper is then applied to the joint in forms such as wire or pastes. The assemblies are then passed through a furnace in which a controlled atmosphere prevents the metals from oxidizing, frees metal from previous oxides, and prepares the surface of the joint to be wetted by the molten copper. As the copper melts, it creeps on the surface of the parent metal and is drawn into the joint by capillary action, forming alloys with the component metals. After the heating cycle, the work is transferred to the cooling chamber, causing solidification of the alloys, and, *after cooling* down to a safe temperature for withdrawal without oxidation, the assembly emerges as a strong, tightly joined part having clear and bright surfaces. This process can be readily substituted for more expensive silver alloy brazing, riveting, pinning, welding, bolting, machining from bar stock or forgings and castings.

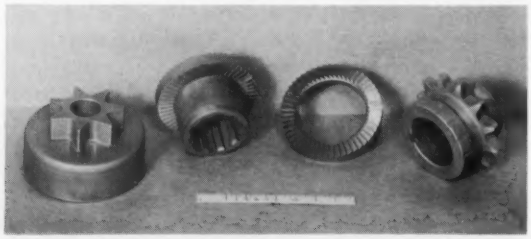


Fig. 1—All these pieces were first brazed and later heat treated. From left: Item #1 was made from low carbon steel and the assembly made with approximately a .002" clearance with a shoulder on the sprocket to locate it on the deep-drawn drum. Items #2 and #3 were made from 4140, pressed together, brazed, and heat treated. In the case of Item #4, the sprocket was carburized before assembly. Then it was brazed, reheated, and quenched to harden the sprocket.

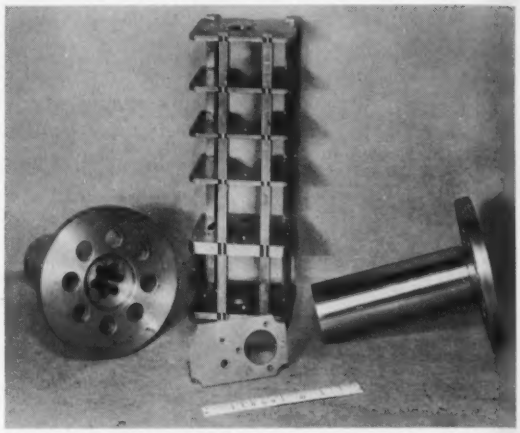


Fig. 2—Small plate assembly in foreground shows how stacking and swaging will hold tubes and pins in place for brazing. Large carrier in center rear, a combination of machined parts and stampings, is held in a rigid frame by press fit of uprights into slots of the shelves. Copper paste is used as a braze medium. Wheel and shaft assembly (left and right) illustrate press fitting against a positive shoulder.

Advantages of Copper Brazing

1. Increased life of sub-assemblies due to greater strength and resistance to vibration and impact.

2. Reduced production costs, resulting from savings in time, material, weight, space, rejection, inspection, and elimination of costly machining operators.

3. Greater strength at high temperature, since copper has a high melting point and good conductivity.

4. Minimum of distortion because parts are heated uniformly, eliminating local stress concentrations.

5. High production rates accomplished since many joints in each assembly can be brazed at one time and because of high production rates per operator.

6. Uniform tightness of joint achieved due to uniform distribution of brazing material through accurate control of the amount applied, of time, temperature, and furnace atmosphere.

7. Flexibility, because light parts may be joined to heavier sections and dissimilar metals may be joined.

8. Excellent appearance and surface conditions because they are controlled by furnace atmosphere and result in clean bright surfaces with smooth fillets at joints.

Preparation of Parts

For the optimum condition of wetting action, the surfaces of the assembly should be perfectly clean. Heavy oils or drawing compounds can be readily removed by the correct composition of most commercial alkali cleaners or vapor degreasers. Equipment can range from an elaborate continuous washing machine for large production quantities to the meager dip tank of carbon tetrachloride or liquid trichlorethylene. Light oils, such as most grades of water soluble oil can be left on, particularly if the oil distills easily or leaves no carbon deposit.

Dust, dirt, or other foreign substances should be eliminated since their presence hinders the flow of the brazing medium. Lead-bearing lubricants should be completely avoided because their presence stops the flow of copper. All parts made of hot rolled steels or heavy with oxide coatings must be machined or cleaned by thorough blasting. Sandblasting is not recommended unless all sand particles are disposed of. Pickling may be used as a cleaning operation, but, here again, care must be executed to remove all smut caused by over pickling. On any hollow body, parts should be *well vented.*

Assembly of Components

Component parts to be copper brazed should be assembled and held together as a rigid structure for copper brazing. The use of jigs or fixtures at the temperature range of 2000-2150°F. is highly impractical due to the cost of greatly increased soaking times. However, in some cases, ceramic fixtures having practically the same co-efficient of expansion as the metal parts can be used.

The most common method of holding is to press fit components together. For best results, press fits of .0005-.0010 per inch in diameter are recommended. Where a heavy section is to be joined to a lighter disc, the joint clearance can be opened to .002 clearance because the mass of heavy section will keep

Fig. 3—Batch-type "L" furnace with pre-heat, high heat, and atmosphere cooling chamber used with either exothermic or endothermic atmosphere.

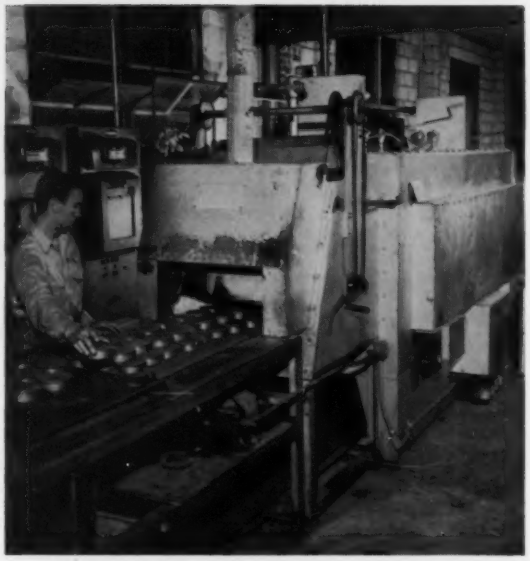


Fig. 4—Typical continuous belt-type copper brazing furnace for turning out high production quantities of light assemblies such as these fan blade pulleys.

the assembly in place. Line contact within the joint instead of uniform tightness can be disastrous.

Spotwelding, tack welding, swagging, expanding, spinning, peening, crimping, riveting, wedging, or even light bolting can be used as methods in holding an assembly rigid at brazing temperature. Also, some assemblies can be wired or clamped to furnace trays or belts.

Applying the Braze Material

There are many forms of copper for brazing; wire, foil, slugs, paste, plating, and molten sprays, and the choice of any depends on the size and shape of the product, quantity desired, appearance of the brazed assembly, and the use of application. The location, form, and quantity are prime factors in the success of a good braze.

The most common form of brazing material is the wire-formed ring since many products have cylindrical components over which the ring may be easily placed. In fact, rings are easiest to control in applying equal amounts of braze material to each and every assembly. The ease of manufacture and the ease of the application keep costs at a minimum. Rings can be formed by hand, wound on a mandrel, or made on automatic machines, depending on quantities. Wire rings should be applied as close to the joint as possible and in such a position as to flow by gravity down the wall of cylindrical members to the joint where it can be drawn into the joint by capillary action. Rings may be embedded in grooves within the the joint, but this method is not too practical unless the length of the joint is exceedingly long. Sometimes, rings can be held in place by a shoulder.

(Continued on page 40)

PROCESSING

JET METALS

By **W. P. BROTHERTON,** *Department Manager*
Ryan Aeronautical Company,
San Diego, Calif.

FROM the beginning of history as we know it until the sixteenth century, only seven metals—gold, silver, copper, tin, iron, lead, and mercury—were known to and used by man. During the following 300 years, seven more metals were discovered. But more than three fourths of the 38 metallic elements were unknown prior to the turn of the present century, and at least 27 known metals were little more than laboratory curiosities in 1950.

Now, as the result of a growing need for high-temperature materials, the searchlight of science is being turned on what might be described as our final metallurgical frontier.

Sheet metal components of jet engines are heat treated in this furnace at Ryan.

Our current need for high-temperature materials is almost exclusively attributable to the development of jet aircraft engines, some of which can blaze away as many as 2,000 gallons of fuel per hour.

Jet engines have posed terrific problems in many fields of production because they basically comprise high-temperature sheet metal structures which are radically different from piston-type power plants whose fundamental components are forgings and castings.

With its ability to produce supersonic speeds at altitudes above 50,000 feet, the turbojet engine is already five times as powerful as the largest of its predecessors; and its installed weight is 75% less than that of any comparable piston engine. Yet engineers declare that the potential of the jet power plant has scarcely been tapped.

Compact engines capable of producing 30,000 hp. are envisaged, if operating temperatures and pressures can be increased, and that is where the mtallurgist is pacing the performance. New materials with better high temperature properties must be synthesized to meet the challenge.

In the combustion chambers and afterburners of existent jet engines, temperatures up to 3700° F. have been recorded. Since this is about 1000° hotter than the melting points of alloys used in such structures, it is evident that the engine materials operate at temperatures in the 1200° to 1800° F. range—thanks to design innovations which center combustion flames and provide for the cooling of engine components with air.

It is possible that design improvements can further reduce the need for heat resistance in jet metals, but it seems unlikely that substantially better engines can be designed without better materials.

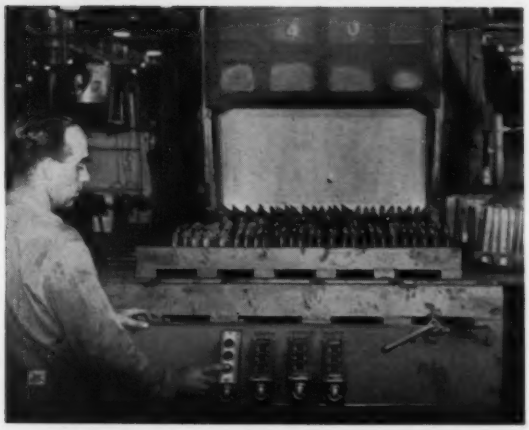
Jet aircraft parts loaded in a controlled atmosphere muffle are ready to be lowered into this heat treating furnace at Ryan.

A number of metals such as tungsten and molybdenum have higher melting points than the maximum operating temperatures of jet power plants, but these elements alone lack the high-temperature strength and oxidation resistance metallurgists are seeking. Accordingly, there is every reason to believe that the future of jet aircraft will depend on the development of new alloys.

Among the materials that are already available, chrome and chrome-nickel steels and alloys with cobalt and nickel bases must now be regarded as the principal jet metals.

Chrome-nickel steels have good oxidation resistance and high strength at elevated temperatures in addition to electrical properties which facilitate welding. However, they are susceptible to distortion when heated, lose ductility when they are cold-worked, and cannot be hardened by heat treatment.

Further, if they are heated to more than 800°F., chrome-nickel steels without columbium or titanium additives lose oxidation resistance due to the precipitation of carbides in their grain boundaries. Their oxidation resistance can be restored by heating them to 1900°F. and quenching them quickly, but this naturally cannot be done in the course of routine engine operations.



Small component fittings for jet engines are heat treated in this furnace at Ryan Aeronautical Co., San Diego, Calif.

When protected with flame-sprayed ceramic coatings, chrome-nickel steel components have been used in combustion chambers and in other jet engine areas where considerable heat is produced. But they are not generally preferred where extreme temperature resistance is required at this writing.

Of the straight chromium materials, steels containing up to 14% chromium have the advantage of being heat treatable for a wide range of mechanical properties because their natural ferritic structures become martensitic if they are heated to 1200°F. or more and rapidly cooled. They are used where excellent mechanical strength is needed at temperatures up to about 1000°F.

Steels with higher percentages of chromium are generally non-heat treatable, but can be used where optimum corrosion resistance is needed at operating temperatures of 2000°F.

Deficiencies of chromium steels include magnetic properties, inferior creep resistance, and welding

Jet aircraft engine assemblies receiving final inspection in Ryan's San Diego plant.

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Annual Achievement Award

The award is made at the discretion of a Committee appointed to select the Best Article appearing in METAL TREATING magazine or Lecture presented at any meeting of the Institute.

This year's award shall be presented at the 1957 Annual Meeting of the Institute, and all Articles appearing in any issue of METAL TREATING from September-October 1956 to July-August 1957 or any Lectures presented at the 1956 Annual and 1957 Spring Meetings are eligible for consideration.

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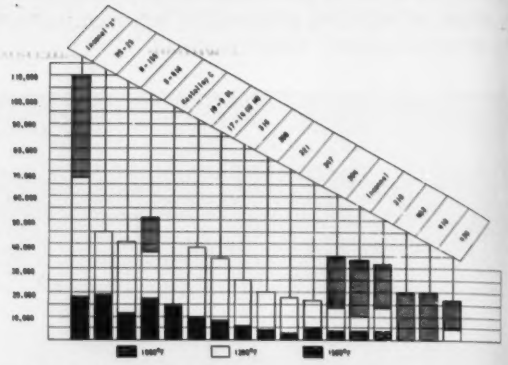
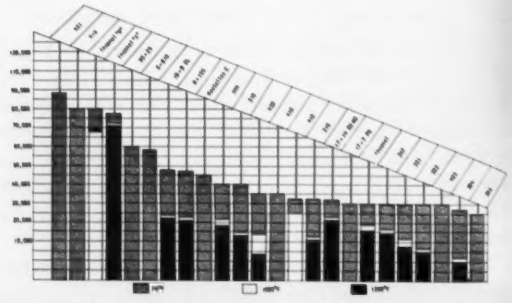


This chart prepared by Ryan Aeronautical Co. shows comparative stress rupture strengths (1,000 hrs.) at different temperatures expressed in psi, and based upon test averages.

characteristics that tend to cause embrittlement.

Preferred nickel-base alloys for jet engines are materials with 70% to 80% nickel such as Inconels, Hastelloy C, etc., since they can have excellent strength and corrosion resistance at temperatures up to 2100°F. and very good fabrication qualities.

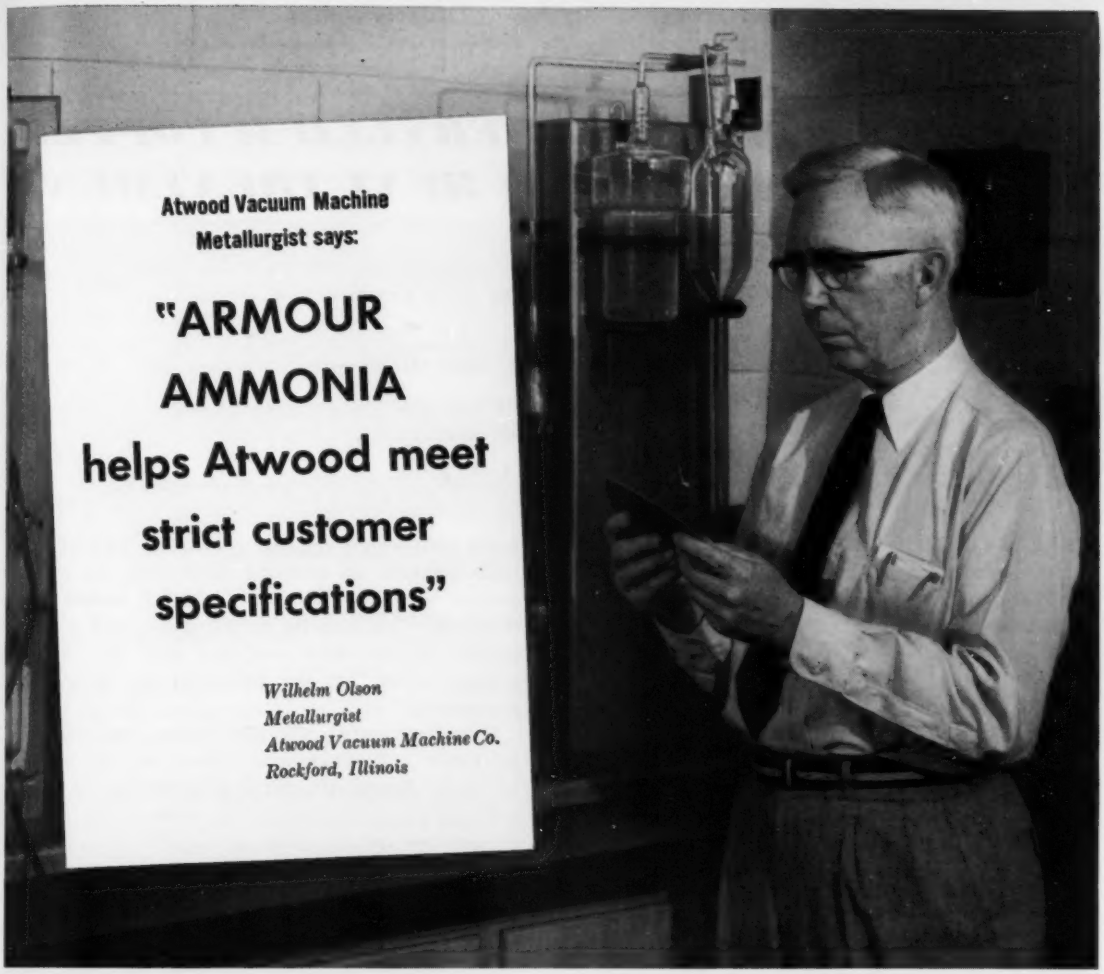
Both heat-treatable and non-heat treatable types of nickel-base alloys are being used. The former, having superior mechanical strength, are employed where operating temperatures will not exceed 1500°F.; the latter, having optimum thermal shock resistance, perform best at higher temperatures.

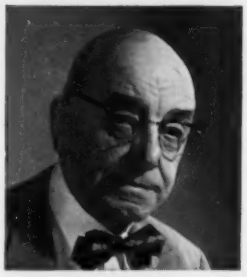


This Ryan chart shows comparative yield strengths (.2% offset) at different temperatures, expressed in psi, and based upon test averages.

Cobalt-base alloys have the disadvantages of being expensive (due to their rare-earth contents) and somewhat difficult to fabricate. However, they now appear to be unexcelled for applications requiring maximum strength and oxidation resistance at temperatures exceeding about 1700°F.

A typical cobalt-base jet metal is Haynes Stellite No. 25, which is now being used to build eyelid assemblies for both afterburners and flameholders. It may be hot or cold worked, much the same as type 347 stainless steel. It has 155,000 p.s.i. ultimate tensile strength, 70,000 p.s.i. yield strength, and 11,000 p.s.i. stress rupture strength at 1700°F. for 100 hours. ■ ■ ■





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THE PROPERTIES OF BERYLLIUM COPPER STRIP AS AFFECTED BY HEAT TREATMENT

By **JOHN T. RICHARDS**, *Chief Engineer*
and
ELLSWORTH M. SMITH, *Chief Metallurgist*
Penn Precision Products, Inc.
Reading, Pennsylvania

PRECIPITATION-hardened beryllium copper strip has found increased application during the past few years for flat springs, diaphragms, bellows, clips, contacts and small structural members on account of its strength, conductivity and corrosion resistance. It is generally furnished in one of several heat-treatable tempers to be formed or drawn, then precipitation-hardened to the desired combination of final properties. Although there is also available mill-hardened or pretempered beryllium copper, this paper is concerned only with the heat-treatable form.

Materials

The alloys studied in this investigation included the standard 2 per cent beryllium copper material meeting the requirements of ASTM Specification B 194 and a commercial material designated as Alloy 165 containing nominally 1.7 per cent beryllium. Eight coils were employed containing varying beryllium contents. In selecting these coils, an attempt was made to limit variations in other elements to a minimum. To simplify handling of data, coils of similar analysis were combined into lots and the average values for the coils making up the lots presented.

Chemical analysis for the various lots are listed in Table 1. Compositions shown are the averages for three determinations at different points in the coil. Maximum variations for these three analyses for any one coil are listed in Column 2. Grain sizes varied from 0.007 to 0.020 mm., while strip thicknesses ranged from 0.0043 to 0.0508 in.

Test Methods

The tensile strength was determined in accordance with the ASTM Methods of Tension Testing of Metal-

TABLE I.—LOT DESIGNATIONS AND CHEMICAL COMPOSITIONS.

Element	Maximum Variation, per cent[a]	Composition, per cent									
		Lot 167	Lot 175			Lot 182	Lot 189				Lot 195
		Coil 1	Coil 2	Coil 3	Lot Averages	Coil 4	Coil 5	Coil 6	Coil 7	Lot Averages	Coil 8
Beryllium	±0.015	1.67	1.75	1.75	1.75	1.82	1.89	1.89	1.90	1.89	1.95
Cobalt	±0.015	0.25	0.26	0.26	0.26	0.24	0.26	0.27	0.27	0.27	0.29
Iron	±0.01	0.14	0.14	0.15	0.15	0.13	0.14	0.14	0.11	0.13	0.14
Silicon	±0.01	0.10	0.10	0.09	0.10	0.12	0.11	0.09	0.08	0.09	0.10
Aluminum	...	0.08	0.05	0.08	0.07	0.06	0.06	0.03	0.02	0.04	0.04
Copper	...	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance

[a] Maximum variations in any one coil resulting from three analyses on each coil.

lic Materials (E8-54T). Tension tests were conducted on a 10,000-lb. Olsen testing machine. Hardness values were obtained from a Rockwell Superficial machine. Grain sizes were estimated by the comparison method.

Values reported are averages from two to six tests.

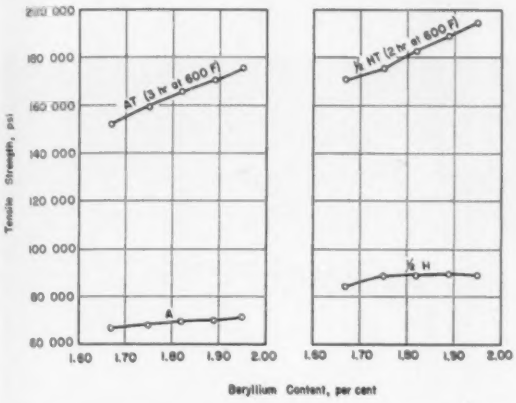


Fig. 1—Influence of Beryllium Content and Precipitation Hardening at 600°F Upon the Tensile Strength of Solution-Treated (A) and Half Hard (½H) Beryllium Copper Strip.

Heat-treated specimens were hardened in either a circulating air furnace or a salt bath. Tensile and hardness specimens were heated loose, without fixtures.

Effect of Beryllium Content

Although composition is known to exert considerable influence upon the aging characteristics of beryllium copper, almost no specific information is available on this subject. Fig. 1 indicates a strengthening effect with increasing beryllium content for both solution-treated (A) and half-hard (½H) strip. Upon aging at 600°F., the improvement in tensile strength with increasing beryllium becomes more pronounced.

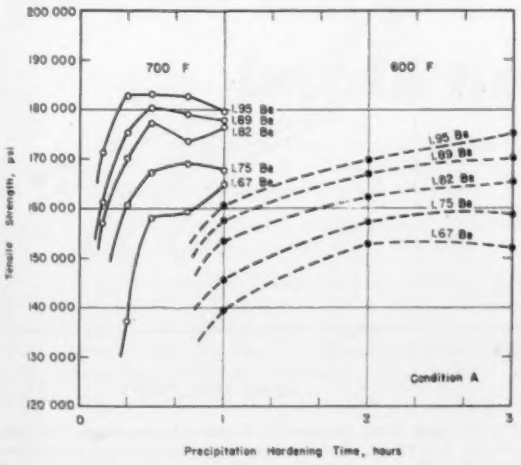


Fig. 2—Comparison of the Aging Characteristics at 600°F and 700°F for Varying Beryllium Contents. Solution-treated (A) strip, 0.0254 in. thick, with 0.015-mm grain size.

In order to study further the influence of beryllium content, a series of hardness response tests were initiated. At the present time, the two most popular heat treatments for beryllium copper are the "standard" 2 to 3 hours at 600°F. and the "short-time, high-temperature" 15 to 30 minutes at 700°F. The former treatment is employed for maximum strength and hardness, while the latter is frequently specified for fixture work, special properties or shorter time cycles.

Figs. 2 and 3 indicate the effect of beryllium content upon aging solution-treated (A) and half-hard (½H) strip at 600°F. and 700°F. At 700°F., lots containing increased beryllium not only harden to higher levels of tensile strength but reach their peak in a shorter period of time. Although 2 hours at 600°F. is generally considered the standard aging treatment for half-hard (½H) strip, Fig. 3 indicates that maximum strength has apparently not been attained in even 3 hours.

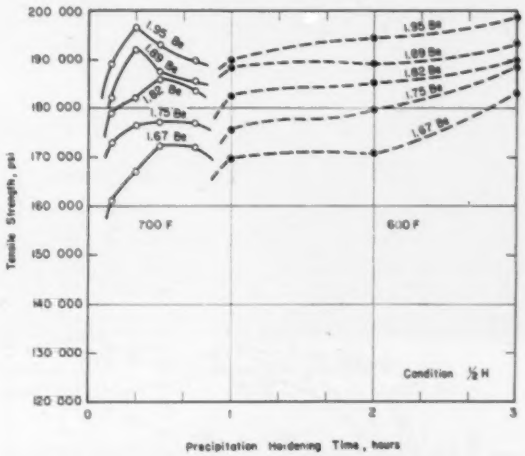


Fig. 3—Comparison of the Aging Characteristics at 600°F and 700°F for Varying Beryllium Contents. Half-hard (½H) strip, 0.0201 in. thick, with 0.015-mm grain size.

Aging Time and Temperature

More detailed hardness response curves are presented in Figs. 4 and 5 for Lot 189 (1.89% Be). All four commercial tempers are included for temperatures from 550°F., to 700°F. In order to present more detail for shorter aging periods, nonlinear time scale is used. These time-temperature relationships once again clearly reveal that the standard heat treatments of 2 to 3 hours at 600°F. do not produce maximum tensile strength.

In 1947 the present authors developed the hardness response curves for Alloy 25 (nominally 2.0% Be) and Alloy 165 (nominally 1.7% Be). Following the reduction in beryllium content to 1.80 per cent that became effective throughout the industry in 1951, it became apparent that the older time-temperature relationships might require modification. The change has been gradual, since the reduction in beryllium content has

been followed by better control over impurity levels during the past several years. Both changes influence aging rates.

To evaluate these possible changes, some of the results of the more detailed study shown in Figs. 4 and 5 are summarized in Figs. 6 and 7. In Fig. 6 the heating times required to produce maximum strength at aging temperatures ranging from 550°F. to 700°F. are presented. The break in the curves at 600°F. for the rolled tempers seems to indicate that aging times at 550°F. were insufficient. Although times up to 8 hours were employed, longer periods are apparently needed at 550°F. to produce maximum strength. At 600°F. periods ranging from 4 to 8 hours are required for maximum strength.

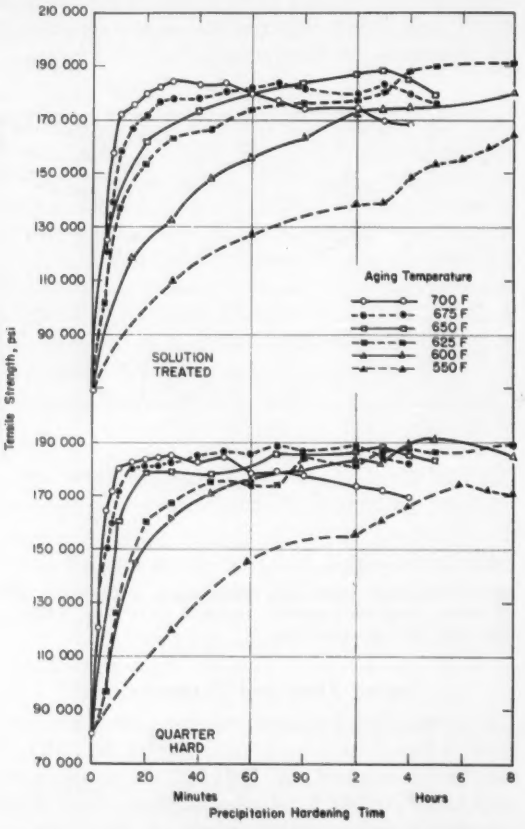


Fig. 4—Effect of Precipitation-Hardening Time and Temperature Upon Tensile Strength of Half-Hard (½H) and Hard (H) Strip. Lot 189 (1.89 per cent beryllium), with 0.015-mm grain size.

As a general recommendation, it has long been felt that heat treatments of 2 to 3 hours are perhaps best for the average fabricator of beryllium copper. In this time range, control of time and temperature need not be critical; furthermore, the problem of "mass effect" with large furnace loads is reduced. Periods over 3 hours are not desirable due to the increase in heat treating costs as well as lower production rates. Therefore, the optimum range of 2 to 3 hours is indicated

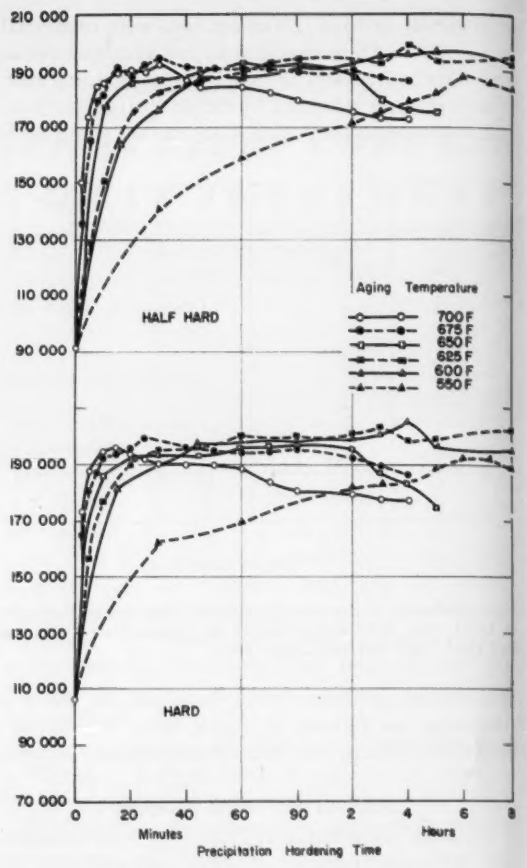


Fig. 5—Effect of Precipitation-Hardening Time and Temperature Upon the Tensile Strength of Solution Treated (A) and Quarter Hard (¼H strip. Lot 189 (1.89 per cent beryllium), with 0.015-mm grain size.

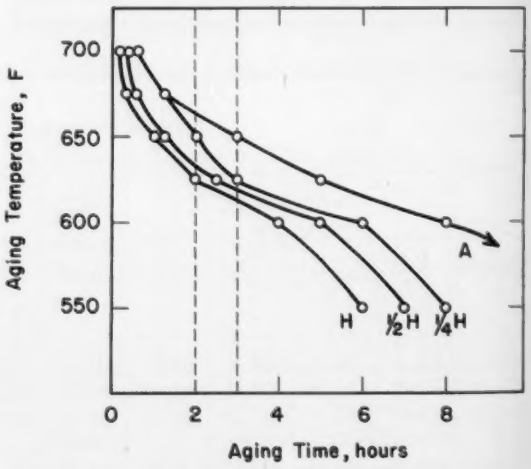
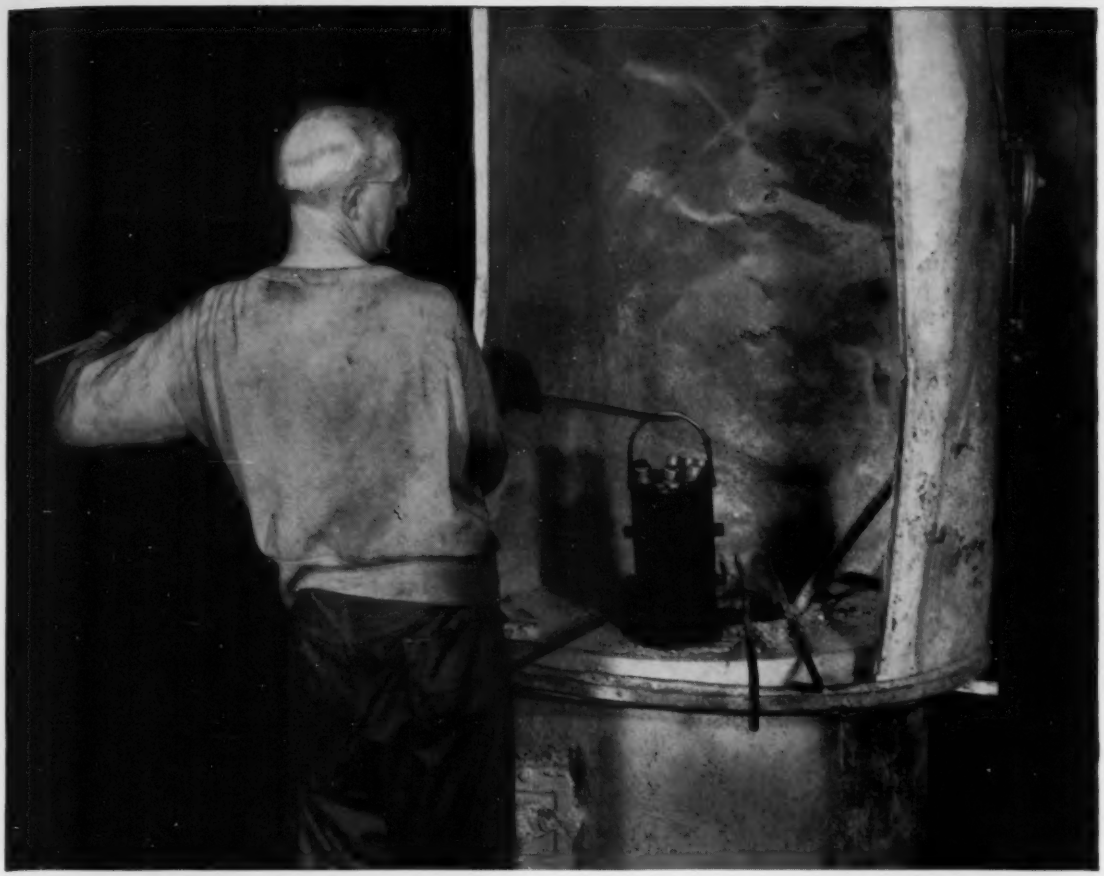


Fig. 6—Aging Time Required to Produce Approximately Maximum Tensile Strength at Various Precipitation-Hardening Temperatures. Lot 189 (1.89 per cent beryllium), solution-treated. (A), quarter-hard (¼H), half-hard (½H), and hard (H).

(Continued on page 60)



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TEMPERING OF HARDENED STEEL

By **K. E. JOHANSSON,** *Head of Metallurgical Laboratory*
Hagfors Jarnverk, Sweden
and
G. MOLINDER, *Head of Metallurgical Laboratory*
Munkfors Bruk, Sweden

THERE is considerable literature available on the tempering of tools made from steel. As a rule this information is given in the form of graphs showing the hardness which may be expected at various temperatures, plus general information as to the procedures to be followed to insure successful hardening and tempering.

Generally, tools are held at heat from 1 to 2 hours per inch of minimum dimension. Therefore, since time and temperature compensate each other to a certain extent, an alteration in the tempering time of a few minutes or even longer, will not affect the ultimate hardness.

However, in the case of components made from thin material, such as Cold Rolled Strip, Cold Drawn Wire or Thin Wall Tubes, where the tempering time is short, the time factor is more important. In order to learn more about this subject, an extensive investigation has been made at the laboratories of the Uddeholm Company's steel mills in Sweden.

The tests were carried out with thin slices from round sections. Before discussing the various hardness curves, it may be well to review some tempering reactions.

When a hardened steel is tempered, a series of reactions take place whereby the tetragonal non-stable martensite as well as non-stable retained austenite are transformed in stages. At sufficiently high tempering temperatures a transformation to cubic stress-free soft ferrite (Alpha iron) and cementite takes place. If large quanties of carbide forming alloys are present in the steel, special carbides also are formed.

At low tempering temperatures, up to about 150°C (300°F), most of the carbon in the martensite is

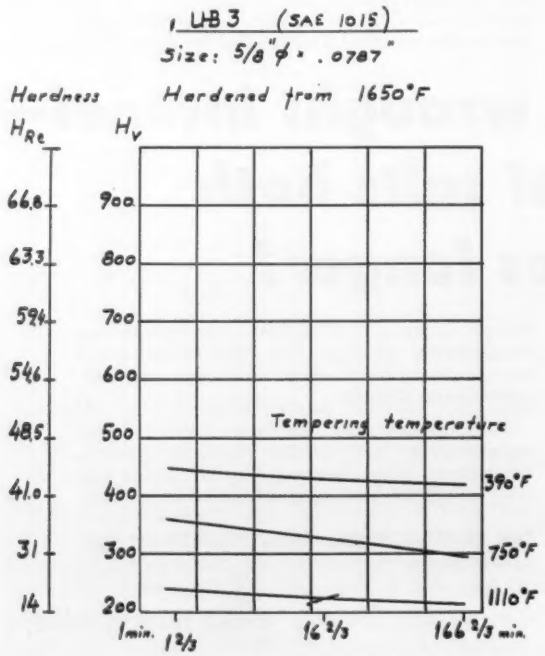


Fig. 1

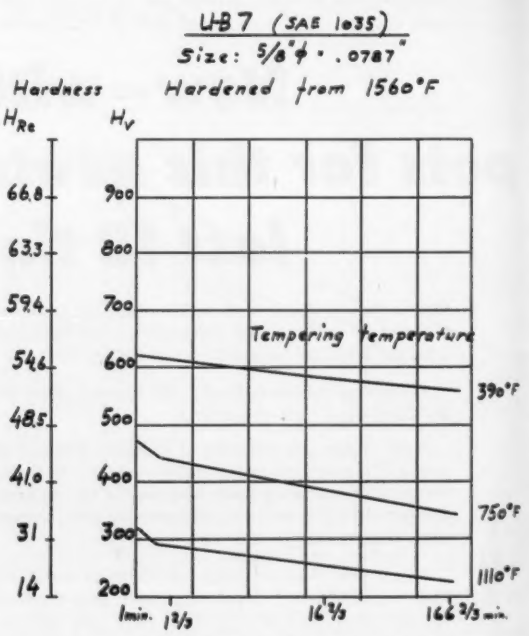
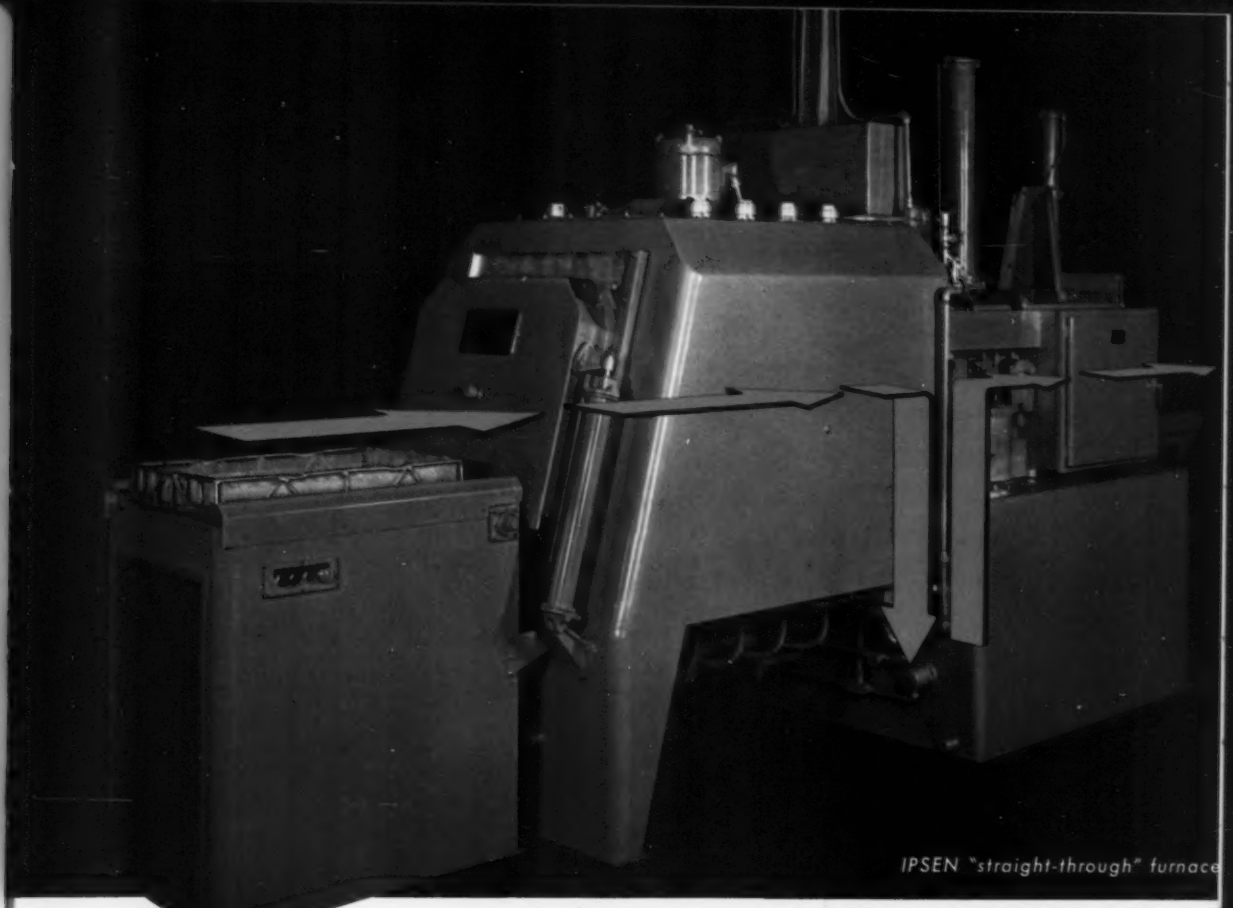


Fig. 2



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following page shows floor plans for both job or continuous installation

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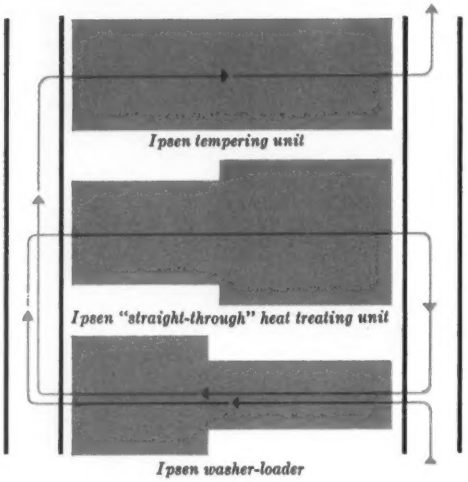

This arrangement includes an Ipsen Washer unit, an automatic "straight-through" heat treating unit, and a tempering unit installed side by side. Two transfer cars operate on crosstracks which connect the three units at both the charge and discharge ends.

Loaded work tray enters the washer . . . emerges from the discharge end to the transfer car which moves the tray to the charging end of the heat treating unit. Tray then enters the work chamber of the heat treating unit . . . passes from the discharge end to the transfer car, then back to and through the washer. The next transfer is into the tempering unit, and the work is ready for the next step of manufacture.

Automatic control of time, temperature, and atmosphere . . . plus the "straight-through" job lot processing features of Ipsen automatic heat treating units offer definite advantages over conventional "in-and-out" job lot type equipment.

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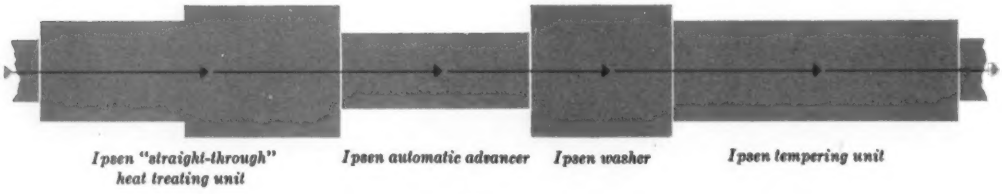

This is a completely automated installation. Special Ipsen-designed mechanisms receive the loaded work trays, move them into the furnace work chamber . . . later transfer them from the discharge end of the heat treating unit to a washer . . . then from the washer to the tempering unit . . . and finally out of the tempering unit to the next processing point.

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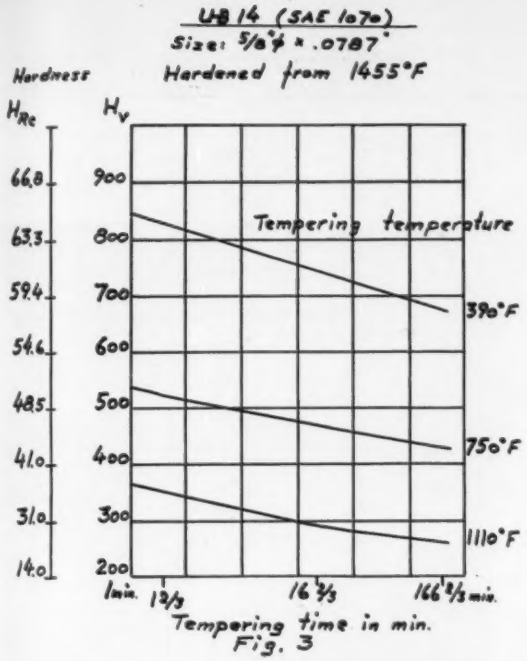


Fig. 3

separated in the form of an iron carbide and the build up of this differs from that of the cementite. Due to the fact that the carbide precipitates in a very fine form and also for other reasons, the hardness of the material increases slightly. This hardening effect disappears when the carbides have grown over a certain size.

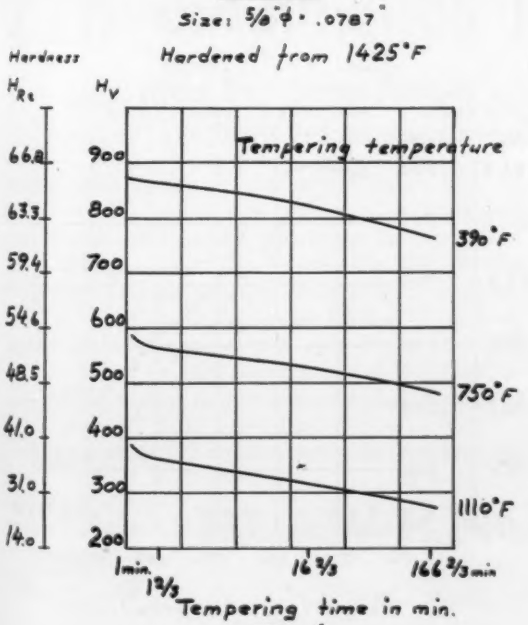


Fig. 4

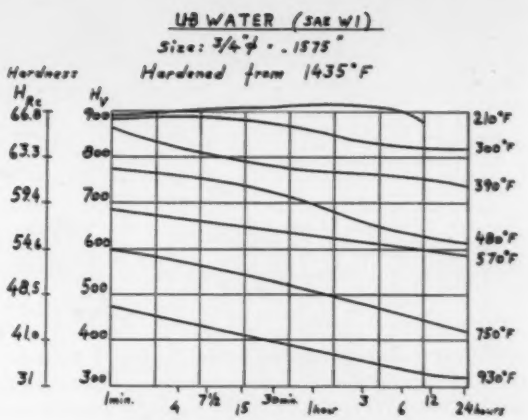


Fig. 5

The iron carbide which forms first is transformed into cementite at temperatures between 150-650°C (300-1200°F). The cementite, which is also an iron carbide, gathers into larger and larger grains and the material becomes softer. At the same time, the retained austenite, which is retained after the hardening, breaks up into ferrite and carbides and this resists the lowering of hardness.

The splitting up of retained austenite takes place in the unalloyed steels at temperatures in the range 150-300°C (300-570°F). With increasing contents of alloys, especially Chrome, Molybdenum, Tungsten and Vanadium a movement towards higher temperatures takes place even up to 500-600°C (930-1110°F) for the higher alloyed cold work—and hot work steels and also the High Speed Steels. Besides the formation and increase in growth of the cementite grains, a new formation of special carbides is formed and the hardness stops decreasing and instead increases. If the tempering temperature is further increased, the special carbides also form into larger and larger grains and the material softens again.

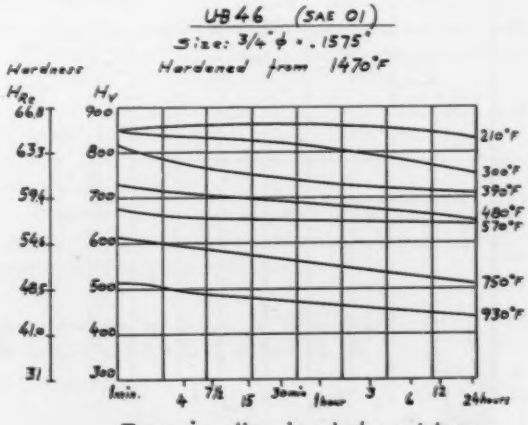


Fig. 6

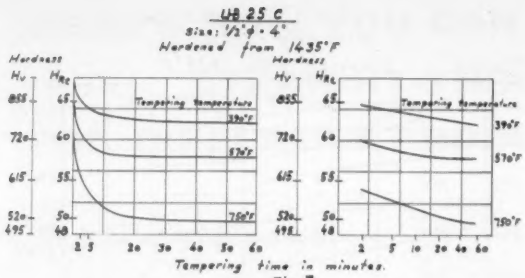


Fig. 7

With very short tempering times, (such as 1 minute) the time required to bring the piece up to full heat reduces the time held at heat in a greater proportion than is the case with long tempering times. A special investigation was made to determine the time required to heat specimens up to given temperatures and it was found that some correction might possibly be made in the case of the shortest tempering times. However, this was not taken in consideration in these tests, as it was found to have very little effect on the end results.

The results are given in the graphs Nos. 1-9 where the hardness is stated as a result of the tempering time on a logarithmic scale at various tempering temperatures. In the figure 8, the tempering time has been set out on a linear scale. In the figures 10-13 the hardness is stated as a result of the tempering temperature at various tempering times.

For the unalloyed and low alloyed steels, it will

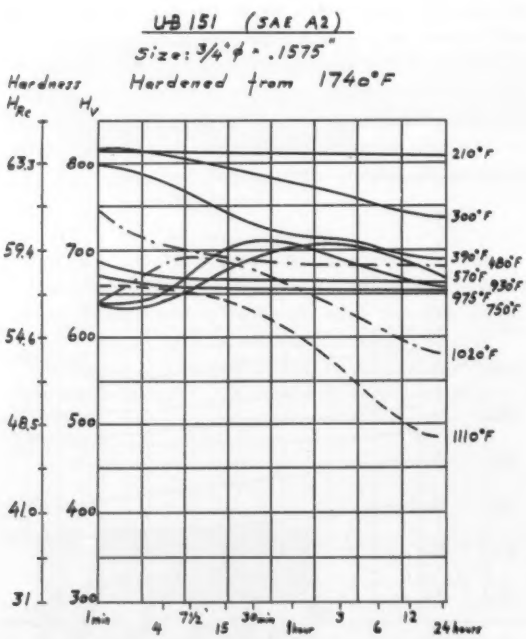


Fig. 8

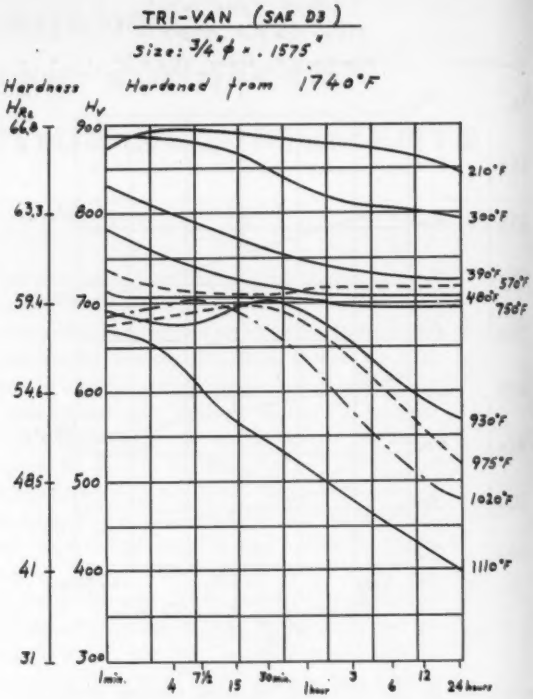


Fig. 9

be seen that the hardness starts to increase between the tempering temperatures of 32-210°F at increasing tempering times to a flat maximum and then starts decreasing. When the tempering temperature is 300°F

(Continued on page 66)

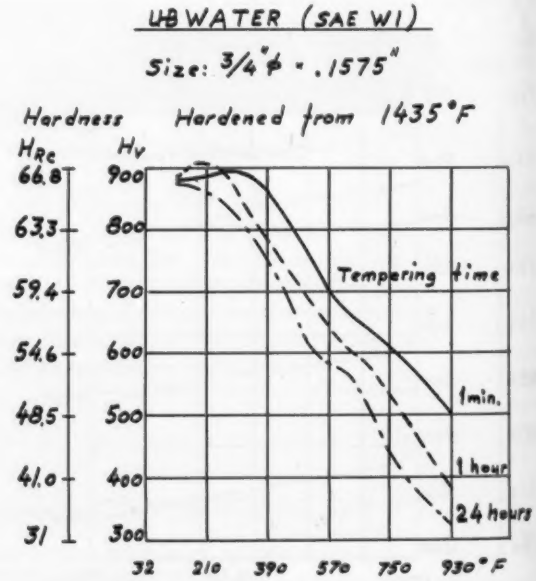
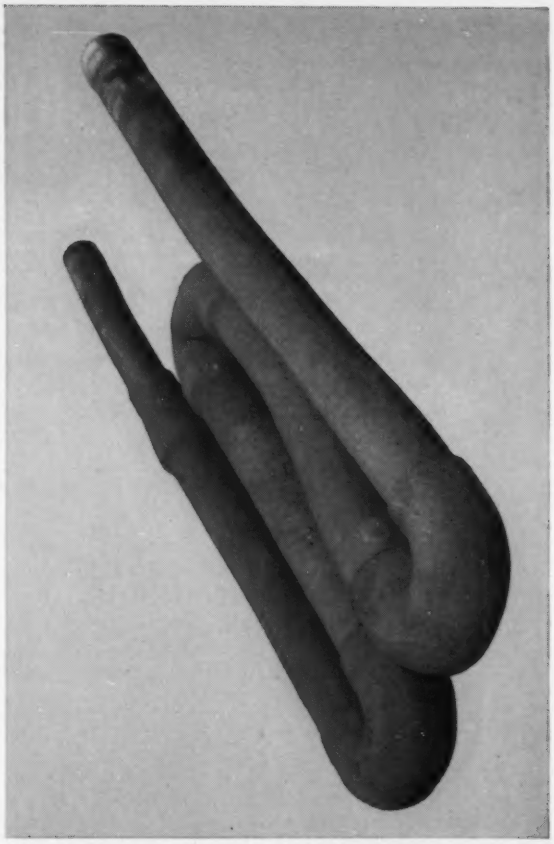


Fig. 10

This unretouched photograph shows deterioration of 25-12 alloy radiant tube after 10 months service.



This unretouched photograph shows radiant tube of 22H still in serviceable condition after 78 months service in the hot zone where temperatures averaged 1850°F.

22H establishes new service record!

Has provided five times longer service life for radiant tubes in annealing furnace... and still going strong

Faced with mounting production losses and increasing tube replacement costs, a manufacturer of continuous weld carbon pipe began to experiment with the new high temperature alloy 22H for the "W" type radiant tubes in his annealing furnaces.

After seven years of in-use testing in all heat zones of the furnaces, this user found that the service life of radiant tubes made of 22H was increased far beyond the performance range of radiant tubes made of 25-12 type alloy.

After a total of 78 months service in temperatures ranging from 1700 to 1925°F., the 22H tubes were found to be in good condition and still continue in service. A 25-12 tube installed in the same position failed after 10 months service.

Since its introduction eight years ago, 22H has proven itself in many applications where severe operating conditions and elevated temperature ranges are the rule.

A National Alloy engineer will be glad to show you further proof of performance, and to discuss the use of 22H in your operation.

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B-7642

BRINELL HARDNESS TESTING

By **LOUIS A. WELT,** *President*
Steel City Testing Machines, Inc.
Detroit, Mich.

"THE best of heat treating 'know-how' or heat treating equipment is no good without good inspection equipment. It is like the old adage, 'A team is only as good as its weakest man'." These are the words of Tom Paterson, Plant Superintendent of Standard Steel Treating Co., one of Detroit's largest heat treaters.

While the science of heat treating has progressed by leaps and bounds over the past many years, there are still enough variables in the handling of any one particular job to require some kind of check on the results.

Basically, there are two types of hardness tests

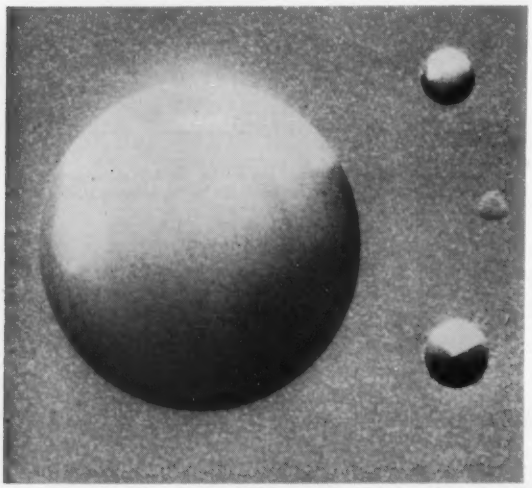


Fig. 1—Impressions made by different hardness testers. Large circle at left is Brinell impression. Upper right is Rockwell "B", lower right is "C". Center right is made by Scleroscope. Photo from *Inspection of Metals*, by Harry Pulsifer, p. 58, published by the American Society for Metals.

generally employed in the heat treating industry. The Brinell hardness test is the one most commonly used when testing castings, forgings, bars and other comparatively soft forms of metal. The Rockwell hardness test is used most commonly to measure surface hardness of tool steels and case hardened material. Rockwell hardness tests are also used on very thin sections and on sheet metal.

The difference between a Brinell hardness test and a Rockwell hardness test can be graphically seen in the accompanying photograph (Fig. 1) which illustrates the comparative size of impressions made by various types of hardness testers. The impressions are identified in the caption beneath the photo, and it can readily be seen that the Brinell impression covers a much greater area than either of the Rockwell impressions. A similar relationship holds true in depth of impression. The result is that a Brinell hardness test covers a much greater area of surface, and a much greater depth, indicating the average hardness of the metal contacted by the spherical ball.

The Brinell hardness test is an indentation test which employs a comparatively heavy load which will crush through a surface crust. It is a test of core hardness as opposed to a test of surface hardness. In effect, the metal beneath the surface is tested and the hardness of the scale will only slightly affect the results. This type of test is particularly useful before machining, and is especially important today to protect the expensive tooling involved in automatic machining operations.

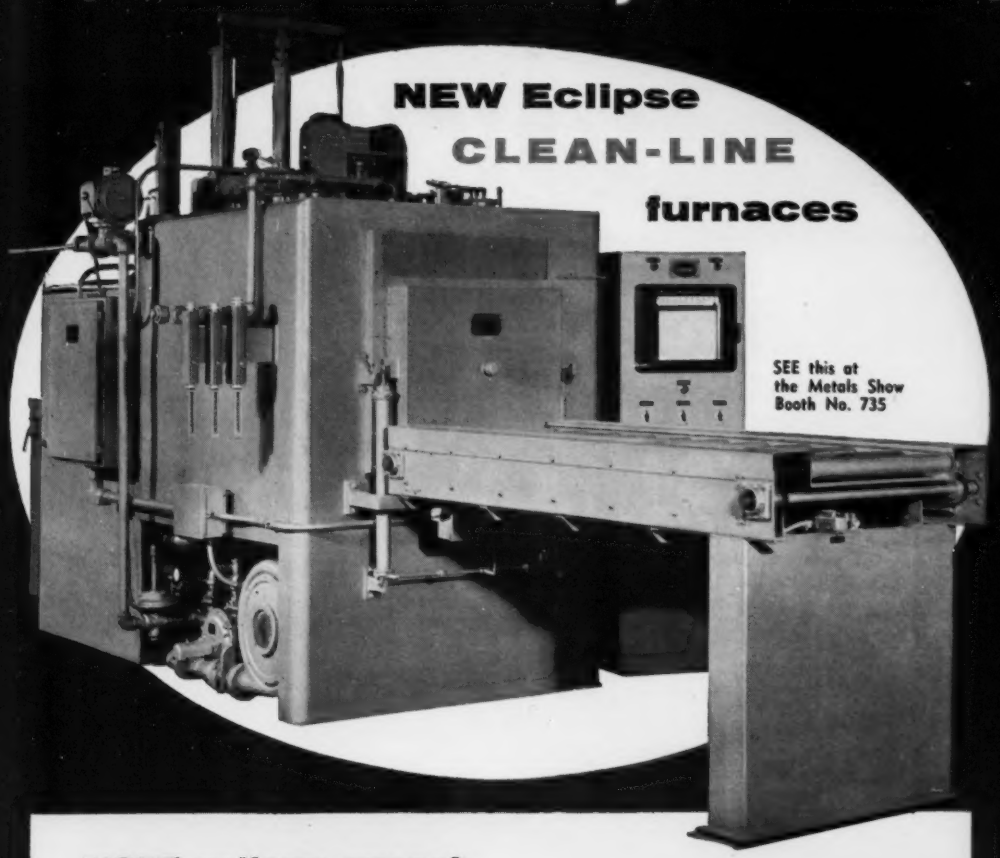
Brinell hardness testers are available in many forms, depending upon the use to which they are to be put. The original type of tester was devised by Dr. J. A. Brinell at the turn of the twentieth century.

The principles set forth by Dr. Brinell, and the formula to determine the Brinell hardness number, have remained unchanged through the years. A known load is applied onto a 10-MM diameter ball which is pressed into the surface of the piece being tested. The diameter of the impression left by the ball is indicative of the hardness of the part in accordance with the formula, although in actual practice tables of Brinell hardness numbers are available from many sources and are usually supplied with a machine. The diameter of impression is measured with a microscope which incorporates a graduated scale in the eyepiece, and the Brinell hardness number is quickly and easily read from this chart.

Modern Brinell hardness testers employ the same principles of applying certain prescribed loads through a 10-MM diameter ball, but the machine has been redesigned for easier use, more fool-proof operation and easier material handling. Likewise, machines have been designed for accommodating larger sizes or unusual shapes so that complete parts can be tested non-destructively for hardness. For laboratory use, strictly dead weight machines, employing lever systems are most popular.

(Continued on page 65)

Brings more uniformity to heat-treating

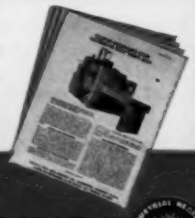


MORE uniform quench
MORE uniform heat
MORE uniform case depth

All these "plusses" are yours with the new Eclipse Clean-Line furnace because: (1) atmosphere and temperature are distributed with complete uniformity during heating — there's no stratification — and (2) even tightly packed loads of the smallest parts are quenched uniformly in the oil jet-agitated tank served by the high-capacity pump. The Clean-Line furnace, rated to heat-treat 400 lb of work in one hour, and with quench capacity for 700 lb per load, is designed for fully automatic clean hardening, carbonitriding, carburizing, carbon restoring, or annealing. Standard Clean-Line furnaces are designed for operation at temperatures up to 1850° F.

Complete control of all heat-treat operations is right at your fingertips. You can select an air or oil quench, for example, just by flicking a switch on the control panel. Heating cycle, high oil pump circulation, and quenching cycle for a particular workpiece can all be controlled precisely and automatically by three separate timers on the control panel. All these features add up to better quality — every piece in every batch.

WRITE for bulletin and data sheets describing the Clean-Line system that includes endothermic generators, automatic washers, and tempering units.



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IHEA

Right Or Wrong In

LABOR RELATIONS

Can You Dock Incentive Workers' Pay Because of Rejects?

What Happened:

The workers were on an incentive system which paid them a bonus of as much as 30% for above-standard output. The company also had a long-standing penalty system by which a worker could lose all or part of his incentive earnings if his work was below acceptable quality. The set-up had been approved on one machine, and Sadler and Vogt ran it alternately for a couple of days. But the parts were so defective that it cost a good deal of time and money to hand-repair them so they could be used. After the company had investigated the matter, part of their incentive earnings were deducted from Sadler's and Vogt's pay checks. They objected, saying:

1. The defective work was due to the company's not keeping the machine in good order. There'd been a lot of trouble with it and many complaints to the foreman. It was finally fixed.
2. There's nothing in our job description which required us to check the parts coming off the machine once the set-up was okayed.
3. The penalty system isn't down anywhere in writing. The company applies penalties in an arbitrary fashion. It ought to be explained clearly in black and white so we know what we're up against.

But the company argued:

1. The defect in the machine, which was corrected after the run Sadler and Vogt turned out, could not possibly have had anything to do with their faulty work. Their rejects resulted from their failure to make a necessary adjustment during the run.

2. It's the clear duty of a machine operator to make periodic checks of the parts during a run. He's provided with a gauge for that purpose.
3. The time standards make special allowances for checking and adjustments during a run.
4. The penalty system has been in effect as long as the incentive system and workers are completely familiar with both. While neither of these systems is part of the contract, they are both well-established practices, in continuous use and accepted by employees.

Was The Company: RIGHT ☐ WRONG ☐

What Arbitrator Maurice Graff Ruled:

"It is readily apparent to the arbitrator that the grievants cannot escape at least a substantial portion of a responsibility for the faulty output of the machine for which they are classified as operators. The operator's job includes the making of the original set-up, the checking of the set-up after a run has begun, the making of any necessary readjustments, and periodic rechecking during the course of a run. The time studies made on this particular job indicate that time has been allowed for the operator to do all of these things. Further there is no denial on the part of any operator that gauges are provided for the checking of output and that they should be used rather frequently. It is apparent that this was not done nor done carefully. Even though the machine was not operating properly and perhaps contributed to the faulty output, we cannot absolve an operator of his clear duty to make a periodic check and to follow standing orders to shut down a machine if the material is not coming out right. Thus we conclude that the major part of the responsibility for the faulty run must rest with men, not with the machine. Clearly the operator did not do all he was expected to do and all he was paid to do. Under the prevailing incentive and penalty systems in this plant, loss of incentive pay and penalty deduction was certainly in order." Grievance denied. ■■■

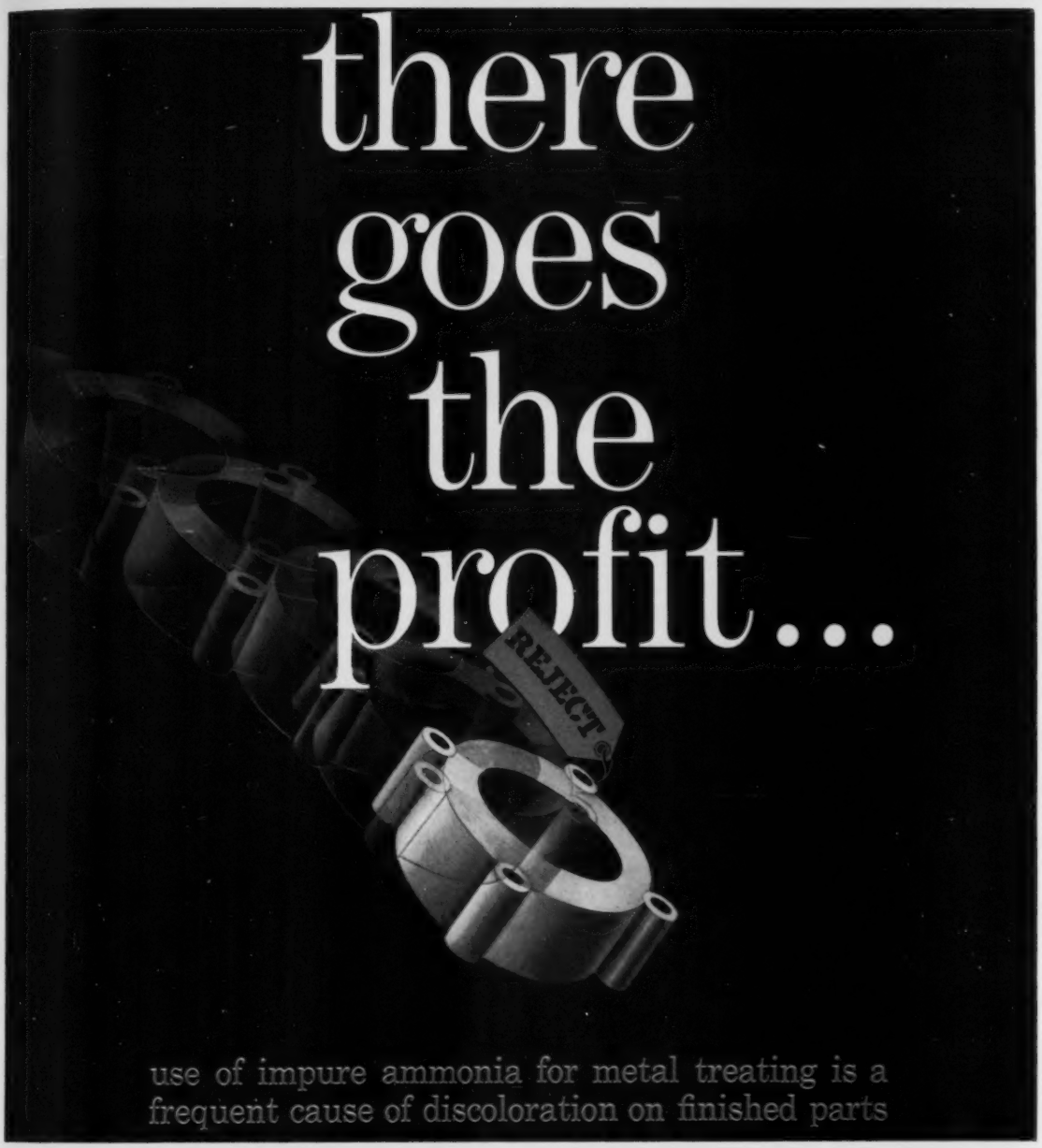
Can You Demote a Worker Who Can't Do All of An Expanded Job?

What Happened:

Vela Morrow was doing a relatively simple job which she performed very well. It was hoped that she could grow and advance to a higher level. Then her job was consolidated with the next higher one. She continued doing only the work she had been doing before—now only a part of the full job. Her foreman didn't want to down grade her, still hoping

(Continued on page 30)

there goes the profit...



use of impure ammonia for metal treating is a frequent cause of discoloration on finished parts

The ammonia you use for metal treating can add to your profits—or reduce them! Impurities like oil or moisture may cause discolorations that land finished work in the salvage box. They are also a common cause of poisoned catalysts and other costly dissociator troubles.

Barrett Brand Anhydrous Ammonia, Refrigeration Grade, protects your profits and production schedules because it's at least 99.98% PURE, DRY ammonia. And each cylinder is double tested to make sure this high standard is maintained.

Barrett Brand Anhydrous Ammonia is stocked in 150, 100 or 50-lb. cylinders by distributors from coast to coast. Tank car or tank truck lots are available from Nitrogen Division's plants and bulk terminals at strategic locations.

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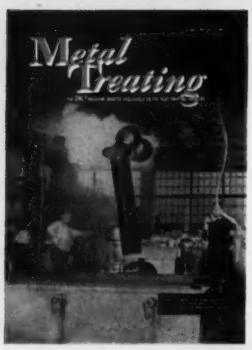
The only magazine devoted exclusively to the Heat Treating Industry



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It is the quality of the editorial content which turns recipients into readers, and what you want to buy is readers.

2. READERSHIP: Editorial content strictly limited to audience interest and properly balanced with advertising content establishes reader acceptance. This is proved by the return of thousands of Readers' Service inquiry cards.

From the last 12 issues over 6,000 inquiries were received, making an average of over 500 inquiries per issue, or 15 per cent of the average circulation receiving these issues. *In addition over 300 "Letters to the Editor" constantly assure us of reader interest.*

3. CIRCULATION DATA: The controlled and BPA audited circulation reaches over 8,000 people—the important personnel who are engaged in some phase of heat treating either in heat treating departments of manufacturing plants or in commercial heat treating plants—all of whom buy your products.

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M.T.I. *Activities*

1957 ANNUAL MEETING

The Annual Meeting of the Metal Treating Institute will be held on November 1, 2, and 3 at the Hotel Sheraton, Chicago.

On Friday, November 1st, Mr. Joseph B. Kuhn, Metallurgist, and Mr. Ethan A. Smith, Jr., Development Engineer, of The Beryllium Corp., Reading, Pa., will present an illustrated lecture on "The Heat Treatment of Beryllium Copper Alloys," and Mr. Horace C. Knerr, President of Metlab Company, Philadelphia, Pa., will present an illustrated lecture on "Nitriding: A Heat Treating Method for Long Life and Negligible Deformation."

Saturday, November 2nd, will feature Mr. Lucas S. Miel, President of Commercial Steel Treating Corp., Detroit, Mich., who will speak on "Cooperation Between Commercial Heat Treaters Within and Without Their Plants." Also, President Bosworth will present his report entitled "Thoughts About the Future of MTI."

Saturday also features a special luncheon in honor of the foreign delegates to the 2nd World Metallurgical Congress who have expressed a special interest in heat treatment. They have been invited to attend this luncheon where they will be given an opportunity to discuss mutual problems and developments involving heat treatment of metals with the members of the MTI.

One of the interesting events of the meeting will be the presentation of the fourth *Annual Metal Treating Institute Achievement Award* to the author of the most outstanding lecture presented at the 1956 Annual Meeting or the 1957 Spring Meeting, or for any feature article appearing in METAL TREATING between the September-October 1956 issue and the July-August 1957 issue.

TWO NEW MEMBERS

The following two companies have been admitted to membership in the Metal Treating Institute with the necessary approval of the Board of Trustees:

Ipsenlab of Rockford, Inc.
2117 Kishwaukee Street
Rockford, Illinois
Mr. Harold N. Ipsen
—President

Kinetics Corporation
2 Churchill Road
Hingham, Massachusetts
Mr. Robert C. Gross
—General Manager

MEMBER FORMS EQUIPMENT CORPORATION

Mr. L. P. Josephs of Pearson Industrial Steel Treating Company, Chicago, a member of the Metal Treating Institute, has recently announced the formation of a new corporation which will deal with the buying, selling, repairing and converting of heat treating equipment. The name of the new corporation is Pearson Equipment Corporation, 5757 West Ogden Avenue, Chicago 50, Illinois.

Pearson Equipment Corporation deals not only in heat treating equipment but also in other equipment and tools, both domestically and in foreign countries.

Mr. Josephs is past president of Pearson International, Inc. and therefore has the proper connections for selling equipment in all foreign countries.

Mr. Josephs also announced that for the sake of brevity the name of the commercial heat treating company had been changed to Pearson Steel Treating Company.

PRESIDENT BOSWORTH SELECTED AS MODERATOR

Eighteen U. S. metal scientists have been appointed as moderators of the international panels that will feature the scientific deliberations of the 2nd World Metallurgical Congress, convening in Chicago this November 2 through 8, under sponsorship of the American Society for Metals.

There will be a total of 17 panels with all sessions being held at Hotel Sherman and with more than 125 metal scientists from overseas and at home appearing.

Howard N. Bosworth, President of the MTI and of Bosworth Steel Treating Company, has been selected as one of the moderators in Panel IV, whose general subject is heat treatment, with the sessions meeting on Monday, November 4. President Bosworth will be moderator for the 2nd Session, whose subject is "Minimizing Distortion."

VACUUM HEAT TREATING FURNACE

Hollywood Heat Treating Company of Los Angeles, Calif., a member of the MTI, has announced the completion of what is said to be the largest vacuum heat treating furnace existing in this country available to private industry.

The furnace measures 99″ in diameter by 10′ 0″ deep; will accommodate a retort 55½″ in diameter by 10′ 7″ deep; and has an effective working zone of 55½″ by 9′ 0″. The furnace will reach a temperature of 2200° F. with vacuum of 1/10 of one micron.

The furnace is now being used to salvage a large quantity of titanium that has picked up hydrogen embrittlement (above 150 parts per million). The company now feels that industry can purchase standard titanium and upgrade the quality by having such a facility.

In addition to degassing and annealing of titanium, the furnace will improve the tensile and physical properties of zirconium, niobium, uranium and stainless steels.

REGIONAL MEETING OF EAST COAST MEMBERS

Fifteen member companies of the Metal Treating Institute, recently sent delegates to attend a Regional Meeting of the Atlantic Coast Chapter of the MTI, held at the Hotel Lexington in New York City.

Thirty delegates attended the all-day session which was highlighted by the illustrated lectures of three excellent speakers:

1. Dr. Thomas Bulat of the Pioneer-Central Division of Bendix Aviation Corp., Davenport, Iowa, whose subject was "Ultrasonics in Cleaning, Quenching, and Other Heat Treating Processes."

2. Mr. Robert F. Spillett, Supervisor of New England Tool Steel Sales, Crucible Steel Company of America, Boston, Mass., whose subject was "Properties and Heat Treatment of Tool and Die Steels."

3. Mr. Harry O. Walp, Jr. of the Vacuum Equipment Division of the F. J. Stokes Corp., Philadelphia, Pa., whose subject was "Vacuum Heat Treating Equipment."

After luncheon and the completion of the lectures, plans were discussed for the next meeting of the Chapter, which will be held on Friday, January 17th, with the location and speakers to be determined later.

Mr. Fred Heinzelman, Jr. was elected Temporary Chairman of the Chapter until its next meeting, and he appointed a Nominating Committee to prepare nominations for Chairman and Vice Chairman to be presented at the next meeting. Members of the Committee are: Chairman, Lloyd Field, and two other members, Philip Keidel and

(Continued on page 31)

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THE APPRENTICE CORNER

SURFACE HARDENING PRACTICES

Part II

By E. J. PAVESIC, *Director of Research*
Lindberg Steel Treating Company
Melrose Park, Illinois

Editor's Note: This is a continuation of the article which appeared in the July-August issue.

Surface Hardening By Diffusion

The methods of surface hardening described below involve a change in surface chemistry brought about by the addition and diffusion of certain elements at elevated temperatures.

Carburizing

The most widely used method of surface hardening employing the diffusion principle is that of carburizing. It has been shown earlier that hardness increases with carbon content and so by increasing the carbon content of the surface of a low carbon steel we are able to satisfy the requirements of high hardness at the surface and toughness (low hardness) in the core.

Carburizing involves heating of the material in the presence of a carbonaceous material, either solid, gas or liquid and holding for a time commensurate with the case depth desired and then quench hardening. The depth of case acquired is governed by: (1) temperature; (2) time; (3) activity or potential of the carburizing medium and (4) the analysis of the ferrous alloy used. Carburizing (and its related processes) is applied generally to low carbon steels of the plain carbon or alloy variety having a maximum of 0.25% carbon. Some typical examples are AISI-SAE C1010, C1018, C1024, C1117, B1112, E3310, 4620, 4817 and 8620. Steels of higher carbon content are sometimes carburized to satisfy special requirements.

Pack Carburizing

The oldest method of carburizing, still in rather common use today, employs solid carburizing compound and is usually termed pack or box carburizing. The compounds generally consist of charcoal and/or coke of high purity to which are added chemicals such as calcium, barium or sodium carbonate which act as energizers. The work to be carburized is packed in a box, pot or other container with the compound, then sealed and subjected to temperatures ranging from about 1550 to 1750°F. Carbon monoxide, liberated by the compound, reacts with the steel forming carbon which dissolves in the austenite and is diffused inward. After the desired case depth is acquired, the work may be cooled in the pot or quench hardened

(Continued on page 31)

Planning Heat Treating Mechanization?

A Mechanized Desanding Operation
This "jack-rabbit" mechanized salt bath line for electrolytic desanding of gray iron castings was designed and supplied in its entirety by Ajax.

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Carburizing or hardening, heating or quenching, whatever the operation may be, the Park man will show you the Park product that will result in more efficient, less costly heat treating. On-the-job tests in plants all over the country have proven that Park heat treating materials mean less rejects, better finishes, and virtual elimination of production tie-ups.

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California Alloy Products Co.
6438 E. Corvette St.
Los Angeles 22, California
Phone: RAymond 3-6487

REPRESENTATIVES

DETROIT—C. R. Foreman, W. P. Askew, L. S. Woodside
CLEVELAND—R. W. Cameron, 19106 Southgate Road, Phone: LOngacre 1-8072
CHICAGO—M. J. Vandenberg, 2008 W. 102nd Street, Phone: CEdarcrest 3-7135
EAST LANSING, MICH.—R. Hammerstein, 1015 Northlawn, Phone: EDgewood 2-3926
CINCINNATI—James F. Hetz, 1313 Mimosa Lane, Phone: GRandview 1-3145
LYNNFIELD CENTER, MASS.—R. H. Settles, 651 Lowell St., Phone: 4-3390
PHILADELPHIA—T. J. Clark, 7240 Lawndale St., Phone: PIlgrim 5-6562

AGENTS

MINNEAPOLIS—Industrial Electro-Gas Equip. Co., Phone: ATlantic 1907
HOUSTON—M. K. Griggs Co., Phone: CApitol 8-2261—7-5523
DALLAS—M. K. Griggs Co., Phone: WHithall 1-4994
ATLANTA—A. J. Mueller Co., Phone: CHerokee 0185
TULSA—Kimball Chemical Co., Phone: GIbson 7-0168
ST. LOUIS—Process Science, Inc., Phone: VIctor 3-1277
TORONTO—J. C. Reid, Phone: CRescent 8-8473

HEAT TREATING HINTS

Tempering—The Final Phase of Heat Treating

In the three preceding issues this column covered the preheating, austenitizing and quenching operations. In this issue we will discuss tempering, the fourth and final phase of a heat treat cycle. Tempering has been defined as reheating of steel, after hardening, to an intermediate temperature range for the primary purpose of toughening the steel. The hardening phase of heat treatment permits the steel to realize full hardness, while the tempering phase conditions the steel so that the hardness can be utilized successfully.

Upon the completion of hardening, the steel is in a highly stressed condition. This hard, brittle phase is produced by the transformation of the relatively soft austenite to a more voluminous structure called martensite. In this condition the steel has a distinct tendency toward cracking and must be handled carefully. Tool and die steels generally are not usable in this state since most applications require some degree of toughness in order to withstand the shock of normal operation. This toughness is gained through tempering. The tempering operation immediately follows the quench for hardening. While it is the easiest and simplest step to perform, its importance cannot be minimized.

By reheating the steel to an intermediate temperature, the hard martensitic structure is broken down and some carbon is precipitated from the martensite in the form of fine carbides. This results in most cases in a slight decrease in hardness. While a loss in hardness is not always desirable, at the same time stress relief takes place within the material, and thus the very high internal stresses which cause the steel to be so brittle are eliminated.

Tempering accomplishes its purpose through a combination of temperature and time. The usual range of tempering temperatures extend from 300 to 1200°F., depending on the grade of steel and the hardness level desired. It is not sufficient merely to heat a hardened part to a certain temperature; it must be soaked at that temperature for a definite length of time. In simple alloys, after the part has reached the tempering temperature throughout the entire section, a one hour soak is sufficient. However, in more complex alloys where diffusion is slower, as for example in the 5% chromium die casting steels, up to a number of hours at temperature is desired. The response to tempering is slow and requires a full measure of time for completeness.

Higher alloyed tool and die steels which are hardened from temperatures in excess of 2000°F. should always be double tempered in order to achieve maximum benefit from this tempering treatment. The reason for this is that on cooling from the first temper, additional fresh martensite is formed from the inevitable retained austenite, and the second temper toughens this newly formed martensite.

Another important factor is the control of time between the quench and temper. The actual hardening takes place at the end of the quenching cycle, and it is readily apparent that tempering too soon will interrupt cooling and will not permit full hardening. On the other hand, if the quenched steel is permitted to remain at room temperature for an extended period of time, the stresses from hardening continue to build up until a point is reached where cracking occurs.

A good tempering practice is just as necessary for a sound tool as is proper hardening. Adequate time spent on tempering is more than repaid in efficient tool life.

Source—Latrobe Steel Company

LETTERS TO THE EDITOR

Dear Editor:

I would appreciate it very much if you would keep my name on your mailing list.

"Metal Treating" is the best magazine devoted to heat treating I have ever seen. I look forward to each issue avidly and have always found the articles and advertisements interesting and informative. There would certainly be a void in my reference library if I didn't receive it now.

W. D. Hagan
Chief Metallurgist
Worthington Corporation
Oil City, Penna.

Dear Editor:

I appreciate very much receiving regularly your very interesting magazine "Metal Treating". I should say, it tells and shows so much in so few words that this is the only magazine I read from cover to cover.

Yvon Courchesne,
Heat Treating Supt.,
Sorel Industries Ltd.,
Sorel, P.Q., Canada.

Dear Editor:

I would like to obtain copies of your magazine "Metal Treating" to be used in my classes on Aircraft Materials and Processes.

Your magazine would serve as an excellent means of keeping up to date on new methods and heat treating techniques.

Any past issues would be helpful in supplementing our reference files.

J. W. Goddard, Instructor
Aircraft Technical Institute
San Diego Junior College
San Diego, Calif.

Dear Editor:

Information is requested as to the availability and cost of your

excellent publication "Metal Treating." I have found many of your articles of great value in connection with my work in Experimental Aircraft.

Ted R. Laukemper
Aircraft Inspector
San Diego, Calif.

Dear Editor:

Your magazine, "Metal Treating" was passed on to me by a friend, and I greatly appreciate the articles and information contained therein.

As I am in charge of the Heat Treat Dept. I would be very grateful if I could be placed on your mailing list.

Edward Harkins
Hall & Pickles Canada Ltd.
Weston, Ontario

Dear Editor:

Battelle Memorial Institute is interested in obtaining reprints of the article, "Heat Treatment of Titanium" by P. D. Frost, which recently appeared in *Metal Treating*, March-April issue. May we have a price estimate?

H. C. Loudenslager
Battelle Memorial Institute
Columbus, Ohio

MTI ACTIVITIES

(*Continued from page* 27)

William Engelhard, Jr.

J. Robert MacAllister

It is with deep regret that we announce the sudden death of J. Robert MacAllister, President of the Syracuse Heat Treating Corporation, Syracuse, New York, on Friday morning, August twenty-third, in the Syracuse Memorial Hospital.

Mr. MacAllister had been a very active member of the Metal Treating Institute, having served on the Board of Trustees and having been the chief author of one of its publications entitled *Manual For Heat Treating Services.*

He had also served as an officer in the Army Transport Corps during World War II, and had studied at Syracuse University.

His brother, John G. MacAllister, is continuing in the management of the commercial heat treating plant.

THE APPRENTICE CORNER

(*Continued from page* 28)

directly therefrom. If the work is cooled in the pot it is subsequently reheated and quench hardened. Pot cooling affords an opportunity to perform further machining operations or the actual removal of part of the case where, for some reason, it may not be desired. While the pack carburizing method is widely used it has many disadvantages. For example, the compound and the container must be heated, compounds are usually dirty and must be continually replenished with new compound to maintain proper carburizing activity. Also it is difficult to control within narrow limits the carbon content of the case and the uniformity of depth. There are however some advantages inherent in pack carburizing not the least of which is the fact that elaborate furnace equipment is not required. The solid compound actually supports the workpieces during the carburizing cycle hence distortion is minimized. The pack method is of real advantage in the shop where the quantity of production is low.

Gas Carburizing

Gas carburizing is another method of surface hardening by diffusion. In this process, the carbon content of a ferrous alloy is increased by heating it in a gaseous carbonaceous atmosphere. Quenching from above the transformation temperature of the case is required for its hardening. This method is the most widely used for carburizing.

Furnace equipment for gas carburizing generally falls into two categories, the batch type and the continuous type. Batch type equipment includes the vertical pit, rotary and horizontal furnaces. Vertical pit equipment may include a gas-tight retort which is heated externally by gas or electricity or it may consist of a refractory furnace, heated by internal gas-fired radiant tubes. The rotary batch equipment consists of a retort which is externally heated by gas while it revolves. The horizontal batch furnace is refractory lined and is heated by electricity or gas-fired radiant tubes within the work load area.

Continuous carburizing furnace equipment includes the following types; shaker or vibrator hearth, chain belt conveyor, rotary hearth, rotary retort and pusher. Methods of heating these furnaces vary but are similar to the methods used for the batch type furnaces. The continuous rotary retort furnace utilizes an alloy retort or muffle as do some pusher furnaces. Regardless of the type of equipment or the method of heating used, the gas carburizing furnace and/or retort must be gas-tight; that is, capable of containing the carburizing atmosphere. Any infiltration of outside air or products of combustion, as from defective gas-fired radiant tubes, might make the carburizing atmosphere ineffective and incapable of control. Recirculating fans are generally used in gas carburizing equipment to promote both temperature and atmosphere uniformity throughout the furnace or retort (work load).

The following gases are used as sources of carbon: (1) natural gas; (2) manufactured coke oven gas; (3) propane; (4) commercial butane and (5) liquid hydrocarbons. These gases or liquids may be used undiluted or the gases may be diluted with so-called carrier gases which are generated in separate equipment. The type of gas or liquid used and whether or not it is diluted is determined by the type of equipment used for carburizing. Generally, undiluted gases or liquids are used in batch retort furnaces while the diluted gases are used in continuous or batch equipment. Unless carefully controlled the use of undiluted hydrocarbons will cause excessive sooting which slows down the car-

(*Continued on page* 36)

Let's LAUGH a minute

Of course everyone knows that heat treating today has become one of the most serious technical and vital functions of the current metalworking activity. But a smile and laughter are still also important and the cartoons shown here are for that purpose.

We hope they make you grin and when it's heat treating services you require or skilled, technical advice about part design or heat treatability, check with

METAL TREATING INSTITUTE
271 NORTH AVENUE
NEW ROCHELLE, NEW YORK

or any member listed on the facing page.

Sound Familiar?
SMEARCASE, THE PRODUCTION MAN, SCHEDULES A JOB THROUGH HIS PLANT WITH TIME TO WASTE!
LET'S SEE... PLENTY OF TIME FOR A GOOD JOB ON OPERATION 1...NUMBER 2 SHOULD BE ABLE TO OOZE ALONG NICELY... AMPLE TIME FOR OPERATION NUMBER 3...THEN OUT IT GOES FOR HEAT TREATMENT
PRODUCTION SCHEDULE
OPER. #1
OPER. #2
OPER. #3
BUT... WHEN THE HEAT TREATER GETS IT... IT'S IN AN AWFULLY GREAT HASTE!
SMEARCASE! HOW'S THAT JOB COMING? TIME'S RUNNING OUT!
FINE, BOSS! I GOT IT TO THE HEAT TREATER 10 MINUTES AGO. I'M CHECKING WITH THEM NOW.
HELLO! ABC HEAT TREATING?
WHAT? NOT THROUGH WITH OUR JOB? DO YOU REALIZE WE HAVE A TIGHT SCHEDULE? TRYING TO MAKE ME LOOK BAD, HUH?.. BLAH, BLAH, BLAH...

Sound Familiar?
CARELESS MILDRED IS NOT PARTICULAR ABOUT THE PARTS HE SENDS IN FOR HEAT TREATING
BUY!...TAKE A LOOK AT THIS CASTING!
...OFF SIZE, WICKED, CRACKED AND WHAT HAVE YOU. HOW DID IT EVER GET OUT OF THEIR PLANT,...OR DON'T THEY CARE?
Smithville Heat Treating Co.
BUT... WHEN HE GETS THEM BACK... WHAM! LOOK WHO GETS THE BLAME!!!
CALL YOURSELVES METAL TREATERS? HAH! YOU SURE GAVE OUR CASTINGS THE 'TREATMENT'-THEY GO OUT OF HERE 100% PERFECT,...AND WHAT HAPPENS? DO YOU DROP 'EM OFF THE ROOF OR JUST RUN A TANK OVER THEM?..IF YOU HAVE NO CONSIDERATION FOR A CUSTOMER'S PRODUCT I'LL JUST HAVE TO...

MTI MASTER CRAFTSMEN
METAL TREATING INSTITUTE

METAL TREATING

CONSULT YOUR COMMERCIAL HEAT THEATER!

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6902 Santa Monica Blvd., Los Angeles 38
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Cook Induction Heating Co.
4925 East Slauson Ave., Maywood

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Commercial Metal Treating, Inc.
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Stanley P. Rockwell Co.
296 Homestead Ave., Hartford 12

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Seneeca Heat Treating Co.
124 S. Batavia Ave., Batavia
Accurate Steel Treating Co.
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Dura-Hard Steel Treating Co.
2112 W. Rice Street, Chicago 22
Pearson Industrial Steel Treating Co.
5757 W. Ogden Ave., Chicago 50
Perfection Tool & Metal Heat Treating Co.
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Fred A. Snow Co.
1942 West Kinzie St., Chicago 22
American Steel Treating Co.
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Eklund Metal Treating, Inc.
721 Beacon St., Loves Park
Lindberg Steel Treating Co.
1975 N. Ruby St., Melrose Park
Ipsenlab of Rockford, Inc.
2117 Kishwaukee Street, Rockford
O. T. Muhlemeyer Heat Treating Co.
1531 Preston St., Rockford
C. U. Scott & Son, Inc.
1510 First Ave., Rock Island

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Quality Steel Treating Company
1630 Locust Street, Anderson

MASSACHUSETTS

Kinetics Corporation
2 Churchill Road, Hingham
New England Metallurgical Corp.
475 Dorchester Ave., South Boston 27
Porter Forge & Furnace, Inc.
74 Foley St., Somerville 43
Greenman Steel Treating Co.
284 Grove St., Worcester 5

MICHIGAN

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Bosworth Steel Treating Co.
18174 West Chicago Blvd., Detroit 28
Commercial Steel Treating Corp.
6100 Tireman Ave., Detroit 4
Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8
Standard Steel Treating Co.
3467 Lovett Avenue, Detroit 10
Vincent Steel Process Co.
2424 Bellevue Ave., Detroit 7
State Heat Treat, Inc.
520 32nd Street, S. E., Grand Rapids 8
Lincoln Heat Treat, Inc.
21235 John R, Hazel Park
Metallurgical Processing Company
2703 East Nine Mile Road, Hazel Park
Royal Oak Heat Treat, Inc.
21419 Dequindre, Hazel Park
American Metal Processing Co.
12000 East Nine Mile Road, Van Dyke

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Metallurgical, Inc.
900 East Hennepin, Minneapolis 14

MISSOURI

Metallurgical, Inc.
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Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15
Paulo Products Co.
5711 West Park Ave., St. Louis 10

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611 Grove St., Elizabeth
American Metal Treatment Co.
Highway 25 and LaFayette St., Elizabeth
Benedict-Miller, Inc.
Marin Ave. and Orient Way, Lyndhurst
Bennett Heat Treating Co., Inc.
246 Raymond Boulevard, Newark 5
L-R Heat Treating Co.
107 Vesey St., Newark 5
Temperature Processing Co., Inc.
228 River Road, North Arlington

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138 Spring St., New York 12
Alfred Heller Heat Treating Co., Inc.
391 Pearl St., New York 38
Lindberg Steel Treating Co.
620 Buffalo Road, Rochester 11
Rochester Steel Treating Works
962 Main Street, E., Rochester 5
Syracuse Heat Treating Corp.
1223 Burnet Ave., Syracuse 3

OHIO

Queen City Steel Treating Co.
2980 Spring Grove Ave., Cincinnati 25
Ferrotherm Co.
1861 E. 65th St., Cleveland 3
Lakeside Steel Improvement Co.
5418 Lakeside Ave., Cleveland 14
George H. Porter Steel Treating Co.
1273 East 55th Street, Cleveland 3
Reliable Metallurgical Service, Inc.
3827 Lakeside Ave., Cleveland 14
Winton Heat Treating Co.
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Ohio Heat Treating Co.
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J. W. Rex Co.
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Drever Company
220 West Cambria St., Philadelphia 33
Lorenz & Son
1351 N. Front St., Philadelphia 22
Metlab Company
1000 East Mermaid Lane, Philadelphia 18
Wiedemann Machine Co.
4272 Wissahickon Ave., Philadelphia 32
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Pittsburgh Metal Processing Co. Inc.
1850 Chapman Street, Pittsburgh 15

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Dominy Heat Treating Corp.
P. O. Box 5054, Dallas
Superior Heat Treating Co., Inc.
P. O. Box 1686, Fort Worth 1
United Heat Treating Company
2005 Montgomery Street, Fort Worth 7
Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11
Lone Star Heat Treating Corp.
5212 Clinton Dr., Houston 20

WISCONSIN

Allied Metal Treating Corp.
830 S. Fifth St., P. O. Box 612, Milwaukee 1
Metal Treating, Inc.
720 South 16th St., Milwaukee 4
Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14
Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4
Wisconsin Steel Treating & Blasting Co.
1114 South 41st Street, Milwaukee 15
Harris Metals Treating Co.
4100 Douglas Ave., Racine

CANADA

B. & W. Heat Treating Limited
70 Borden Ave., S. Kitchener, Ontario
Ipsenlab of Canada Limited
27 Bermondsey Road, Toronto 16, Ontario

INSTITUTE **271 NORTH AVENUE**
NEW ROCHELLE, NEW YORK

NEWS TO HEAT TREATERS...

HEAT TREATMENT GROUP OF 2nd WORLD METALLURGICAL CONGRESS

The foreign delegates attending the 2nd World Metallurgical Congress have been divided into various groups according to their interests, and one of these, is the Heat Treatment Group. The committee in charge of arranging a program of plant visitations and lecture sessions for the group is as follows: Dr. A. E. Focke, Chairman, Manager of Materials Development, Nuclear Propulsion Department, General Electric Company, Cincinnati, Ohio; Mr. Howard N. Bosworth, President of the Bosworth Steel Treating Company, Detroit, Michigan; and Mr. Walter Holcroft, President of Holcroft & Company, Detroit, Michigan.

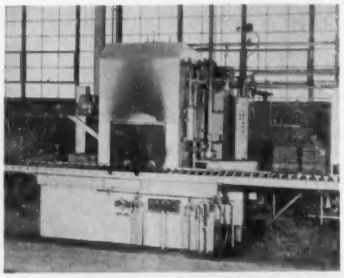
This Heat Treatment Committee has planned plant visitations at the following commercial heat treating plants: on October 22nd the Drever Company and Metlab Company, both of Philadelphia; and on October 30th the Commercial Steel Treating Corp., and Bosworth Steel Treating Company, both of Detroit. All four companies are members of the Metal Treating Institute.

The delegates have also been invited to attend a special luncheon in their honor being given by the Metal Treating Institute on Saturday, November 2nd at the Hotel Sheraton in Chicago. The delegates will be given an opportunity to discuss mutual problems and developments involving heat treating with the MTI members. The Institute, the national trade association of commercial heat treaters, is having its Annual Meeting in Chicago from November 1-3, just prior to the Metallurgical Congress.

Monday, November 4th. has been set aside for lecture sessions and panel discussions for the Heat Treatment Group attending the Congress. The first session will be 9:00 a.m. at Hotel Sherman in Chicago, and the subject is "Carburizing" with Mr. Walter Holcroft, President, Holcroft & Company, acting as Moderator. The second session will be at 2:00 p.m. with the subject being "Minimizing Distortion," and the Moderator, Mr. Howard N. Bosworth, President, Bosworth Steel Treating Company, and President of the MTI.

CONTROLLED ATMOSPHERE FURNACE

New design and operational features have been announced by the Dow Furnace Company, Detroit, Michigan, in connection with their model HD-1200 batch-type, controlled atmosphere, heat-treat furnace.



The HD-1200, with a gross heating rate of 1200 lbs. per hour to 1500°F has a temperature range of 1450°F to 1700°F. It has a wide heat-treat process range including carburizing, carbonitriding, carbon restoration and clean hardening.

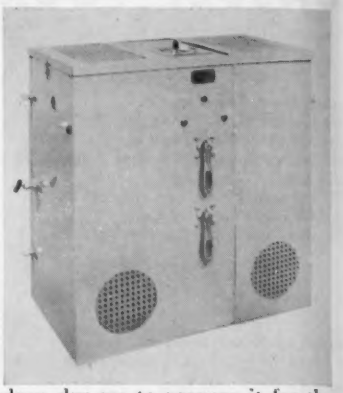
For further information circle No. 1

GAS PURIFICATION SYSTEM

Atmospheres dried to 1 p.p.m. of moisture or other contaminants are now possible with the new gas purification line recently announced by Air-Dry Corporation of America.

Automatic operation is accomplished by combining two complete systems with suitable automatic transfer controls which permit reactivation of one system while the other is in the purification cycle.

Reactivation consists of removing the contaminants from the dessicant, then purging the system with clean dry gas to prepare it for the next duty cycle. Semi-automatic equipment is also available for those applications where it proves to be more suitable.

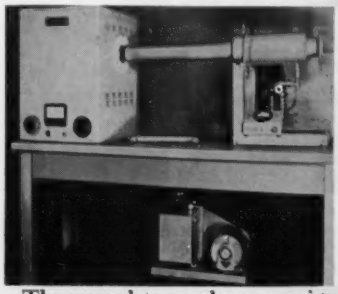


For further information circle No. 2

VACUUM RETORT PACKAGE UNIT

A self-contained, complete package unit for processing small parts in a vacuum or protective atmosphere has been announced by Lindberg Engineering Company, Chicago.

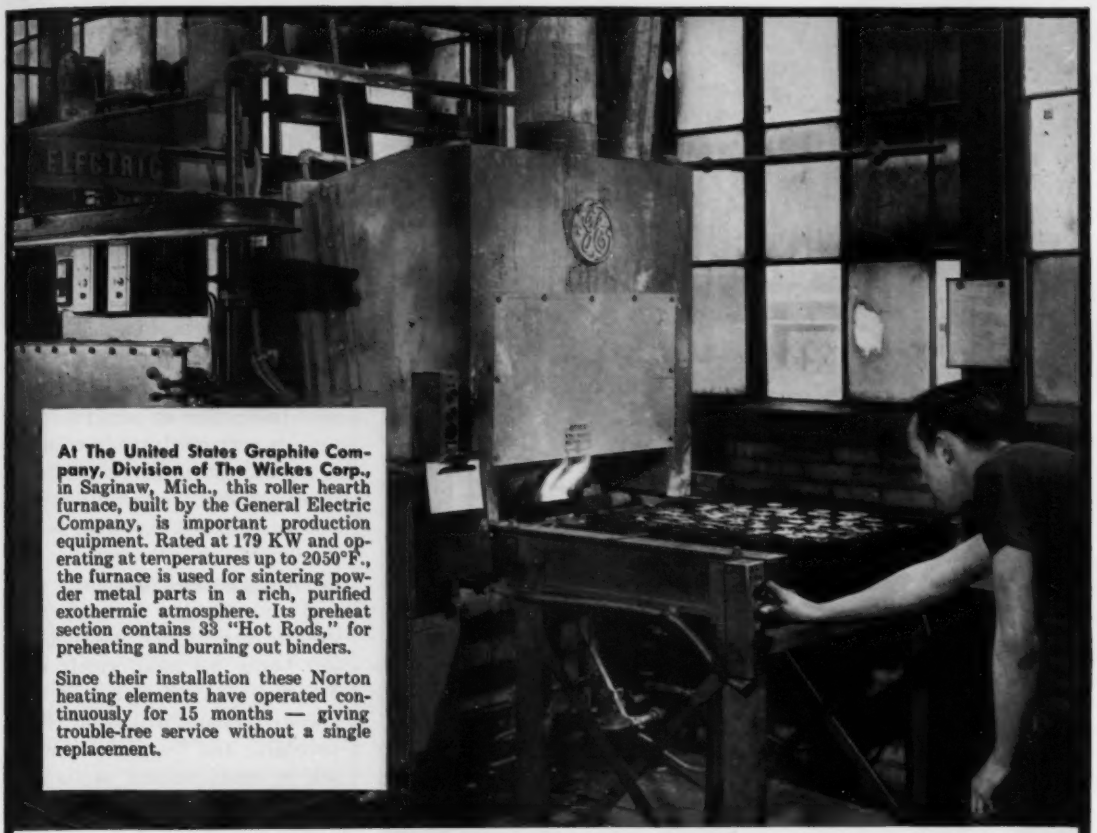
The processing is accomplished in a vacuum retort satisfactory for temperatures up to 2000°F. at a vacuum of 0.5 micron or better. The work is heat treated and cooled in the same tube.



The complete package consists of a furnace, automatic controller, pyrometer, 3" I.D. tube with water-jacketed cooling chamber, track and accessories for inserting tube into heat zone, 7" work boat, mechanical vacuum pump, diffusion pump and vacuum gauge . . . all mounted on a steel work table.

For further information circle No. 3

(Continued on page 38)



At The United States Graphite Company, Division of The Wickes Corp., in Saginaw, Mich., this roller hearth furnace, built by the General Electric Company, is important production equipment. Rated at 179 KW and operating at temperatures up to 2050°F., the furnace is used for sintering powder metal parts in a rich, purified exothermic atmosphere. Its preheat section contains 33 "Hot Rods," for preheating and burning out binders.

Since their installation these Norton heating elements have operated continuously for 15 months — giving trouble-free service without a single replacement.

At The United States Graphite Company...

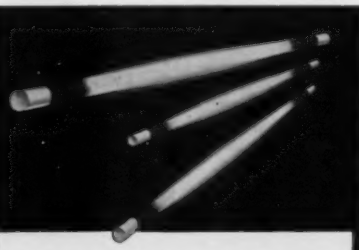
"HOT RODS" give long lasting service life

Norton CRYSTOLON heating elements are excellent performers in an Electric Sintering Furnace*

Norton "Hot Rods" are outlasting other non-metallic heating elements *up to 3 to 1!* Such reports from many plants mean that you too can save with these heating elements, because they need less replacing than other elements. Also, you get reduced maintenance, due to less changing of elements or voltage taps. And "Hot Rods" help protect product quality, because their slow, evenly matched rate of resistance provides more uniform heating.

For further facts on how "Hot Rods" can help improve your furnace operations and cut costs, send for booklet, *Norton Heating Elements.* NORTON COMPANY, Refractories Div., 628 New Bond St., Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries



Norton CRYSTOLON Heating Elements, or "Hot Rods," are a typical Norton R_x — an expertly engineered refractory prescription for greater efficiency and economy in electric kiln and furnace operations. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes.

NORTON

REFRACTORIES

Engineered... R_x ...Prescribed

Making better products... to make your products better

NORTON PRODUCTS

Abrasives • Grinding Wheels
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BEHR-MANNING DIVISION:

Coated Abrasives • Sharpening Stones
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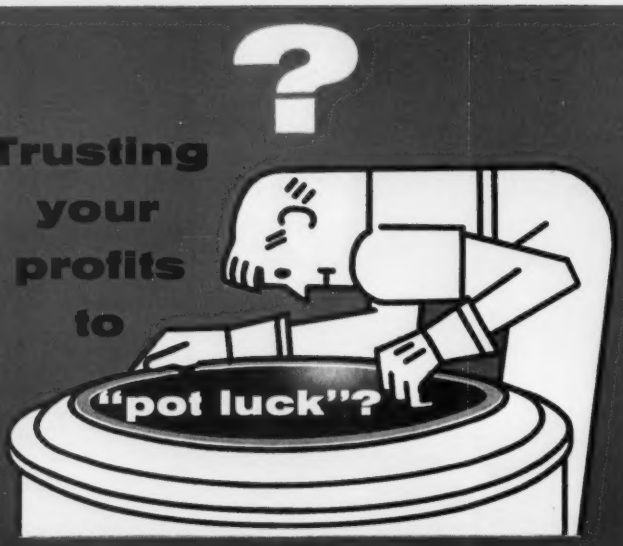

You know where you stand with pressed steel!

• A cast steel or alloy pot can easily have a concealed flaw —undetectable by visual inspection—which *at any one heating* may produce a break resulting in major repairs on brickwork, burners, and controls. Eclipse Pressed Steel pots cost only one-third as much as cast pots . . . yet *cannot be defective!* No defective steel survives the stresses of drawing. Switch to pressed steel pots and you switch to *scheduled* pot maintenance that puts your profits on a *predictable* basis. What's more, Eclipse pots *weigh only half as much* and have higher thermal conductivity! That means substantial fuel savings and faster, better controlled heating. Eclipse Pressed Steel pots are formed from highest quality firebox open-hearth mild steel, from the heart of the ingot, with a perfectly uniform 3/8-in. section. They're practically impervious to corrosion. Write for illustrated catalog and price list—78 standard pots available immediately from stock! For lead, salt, cyanide, oil-tempering, metal-melting.

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street, Rockford, Illinois
ECLIPSE FUEL ENGINEERING CO. OF CANADA, LTD.
20 Upjohn Road, Don Mills, Ontario

Eclipse® INDUSTRIAL COMBUSTION DIVISION

THE APPRENTICE CORNER

(*Continued from page* 31)

burizing rate and is deleterious to furnace or retort.

Carrier gases used to dilute the hydrocarbon gases are prepared in special generators and are by comparison with the hydrocarbon gases relatively ineffective carburizing mediums. Their use is intended primarily to supply a sufficient volume of gas to the carburizing furnace or retort to maintain a positive furnace pressure and to prevent infiltration of air. The addition of controlled amounts of hydrocarbon gases then provide the necessary carburizing activity or potential. Excessive sooting is thus minimized or eliminated. Rich exothermic, endothermic, charcoal and nitrogen base gases are used as carrier gases, the endothermic being the most widely used. Endothermic carrier gas is the most popular because it is relatively inexpensive and because it lends itself to ready control of composition (carbon potential.)

The mechanics of gas carburizing involve heating the ferrous alloy in equipment as described above containing the carburizing gas to a temperature of 1550 to 1750°F and holding for a time commensurate with the required case depths and then cooling in any manner desired. The carbon in the atmosphere is liberated and dissolves in the austenite and is diffused inward toward the lower carbon core. The rate of carburization is dependent upon temperature, time activity or carbon potential of the atmosphere and to a lesser extent upon the type of steel used. For example in 8 hours at 1600, 1650 and 1700°F case depths of approximately 0.050, 0.060 and 0.070 respectively are obtained on a plain carbon steel.

After carburizing, the workpieces are either slowly cooled or direct quenched. If slowly cooked, they are subsequently reheated above the transformation temperature of the case and/or core and

quenched. By regulating the quenching temperature, varying properties can be produced in the case and core to satisfy a variety of requirements. Case hardnesses of Rockwell C 60 minimum are easily attained.

Gas carburizing has a number of advantages over pack carburizing of which the following are the most important: (1) heating times are faster since only the workpieces are heated; (2) gases are more readily amenable to control and reproducibility, hence case depths and carbon concentrations are more consistent; (3) gas carburizing is much cleaner and requires less space.

Carbonitriding

As the term implies, carbonitriding is a process for surface hardening by the simultaneous addition and diffusion of carbon and nitrogen. The process employs a gaseous atmosphere containing hydrocarbons (as in gas carburizing) to which is added nitrogen in the the form of raw ammonia. The process is carried out in equipment similar to that used for gas carburizing at temperatures ranging from about 1425 to 1625°F to produce case depths of from 0.001 to approximately 0.032" maximum. Liquid quenching is employed when parts are carbonitrided in this temperature range and hardness of Rockwell C 60 minimum is attainable by varying the atmosphere composition to include a very high percentage of ammonia and processing at temperatures of 1200-1450°F. A hard case can be produced which is extremely high in nitrogen content and which does not require liquid quenching. Because of low diffusion rates at temperatures of 1200-1450°F this practice is only used on applications requiring a file hard skin or on parts the dimensions of which would be difficult to control if they were processed in the normal manner and liquid quenched.

Carbonitriding in recent years has to a considerable extent replaced other liquid case hardening methods. The principal advantages of carbonitriding over liquid case hardening methods are: (1) lower cost of raw materials (gases); (2) permits oil quenching (less distortion); (3) carbonitrided work is easier to clean; (4) eliminates use of toxic materials and it is cleaner (no fuming, drag-out, etc.); (5) equipment used is more versatile and can be used for other processes. Disadvantages include higher cost of equipment and its inability to produce economically case depths above 0.032".

Liquid Carburizing

This method of carburizing employs molten salts containing cyanides which provide the source of carbon. Nitrogen in small amount may also be absorbed by the steel. The bath is comprised of varying mixtures of sodium cyanide, sodium carbonate and the chlorides of barium, calcium, potassium, sodium and strontium. The bath is operated at temperatures of 1600 to 1750°F with a sodium cyanide content of approximately 10%. The liquid carburizing bath is operated with a carbon cover, the carbon being incorporated in the initial mixture. Liquid quenching in brine, oil or water is required

General Alloys' Radiant Tube Assemblies combine castings and fabrications to obtain the best features of each for optimum performance and service life.

The cast return bends give uniformity and extra strength at the area usually susceptible to early failure. The fabricated straight sections are light weight and provide maximum efficiency for heat transfer.

General Alloys combination cast and fabricated Radiant Tube Assemblies are available in many types of heat and corrosion resistant alloys, in a wide range of shapes and sizes to meet your specific requirements.

Extensive experience in high alloy castings and fabrications, together with modern production and testing facilities, is your assurance of superior results and satisfaction.

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to harden the case. Case depths attainable by this process are comparable to those of other carburizing processes such as the gas and pack methods. For example in 4 hours at temperatures of 1600, 1650 and 1700° F, case depths of approximately 0.033, 0.038 and 0.047" respectively are obtained. Liquid carburizing baths are generally used for the range of case depths from about 0.032 to 0.250". Case hardness is comparable to that produced by other carburizing processes.

Accelerated and Water Soluble Liquid Carburizing

In recent years, the liquid carburizing baths have been modified in composition by the addition of catalysts to increase the carburizing activity and to improve the washing or cleaning characteristics of the salts from the work so treated. These modified baths are generally termed accelerated and/or water soluble carburizing baths. A carbon cover must be maintained on such baths. They are operated in the temperature range of 1500-1700°F to produce case depths from about 0.005 to 0.050". For example, in 1 hour at temperatures of 1500, 1600 and 1700°F case depths of approximately 0.010, 0.020 and 0.025" respectively are obtained. The case produced is high in carbon and contains some nitrogen. Liquid quenching is required to harden the case and hardnesses of Rockwell C 60 minimum are easily attained. ■■■. *(Part III will appear in the next issue).*

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Repeat purchases by prominent Heat Treaters is their endorsement of the superior performance and economy of our Vertically Corrugated Retort.

We will cooperate with your Engineering Organization in designing your Alloy steel fabrications and other metal and non-ferrous metal fabrications.

We have facilities to form ⅜" thick by 10 ft. long steel in our 500-ton Press Brake; heavier plate in shorter lengths. We also have facilities for roll forming heavy and thin wall cylinders to almost any diameter you specify.

We have 25 years experience fabricating for the Heat Treating Industry and corrosion resisting metals for the Chemical Processing Industries.

We solicit your inquiries for Retorts, Boxes, Baskets, Trays, Radiant Tubes and Fixtures etc. used in the Heat Treating Industry.

For further information send for literature

ALUMINUM and ARCHITECTURAL METALS COMPANY

Heat Treating and Industrial Processing Accessories Division

1974 Franklin Street
LOrain 7-6880
Detroit 7, Michigan

NEWS TO HEAT TREATERS

(Continued from page 34)

HARDNESS TESTING EXHIBIT

The latest advances in the art of hardness testing of metals, including fully automatic console and floor model hardness testers that are being successfully used in industry for quality control checks, will be featured in Booth No. 953 by the Wilson Mechanical Instrument Division, American Chain & Cable Company, Inc., at this year's National Metal Show. The exhibit will be held at the International Amphitheatre, Chicago, November 4-8.

On display will be the Motorized Rockwell hardness tester which is semi-automatic in operation. Known as the model YR, this device features a short test cycle to permit an increased number of Rockwell readings to be taken and recorded within a definite time period. A special dial gauge, designated as the Set-O-Matic, eliminates the necessity of the operator setting the dial bezel for each test.

In addition, the Wilson Mechanical Instrument Division will also display its regular line of hand-operated Rockwell and superficial Rockwell hardness testers, the Tukon microhardness tester, and accessories for all models, including the Equitron fixture which is used for holding pieces that are being tested for Jominy hardenability.

For further information circle No. 4

RUST PROOFING

Heatbath Corp. announces a new product "Rustgard" for inbetween rust proofing of ferrous metals. Rustgard is a water soluble material containing a powerful rust inhibitor. It is mixed 1 to 20 parts

with water and applied by immersion or spray at temperatures up to 212°F. It is used on ferrous metals to prevent rust after machining, stamping, drawing and forging; during assembly, storage and shipping; and as a final protective finish over conversion coatings such as black oxide and phosphates.

For further information circle No. 5

I.H.E.A. SPEAKERS AT WORLD METALLURGICAL CONGRESS

For the benefit of metalworking people throughout the world, and in the interest of a free interchange of technology between competitive Association members, the Industrial Heating Equipment Association under the auspices of the American Society for Metals will present a half-day symposium during the World Metallurgical Congress in Chicago.

Theme of the I.H.E.A. program will be "Modern Equipment Speeds Metallurgical Processes." The session will be held from 9 to 12 a.m. Tuesday, Nov. 5, in the Red Lacquer Room of the Palmer House.

Speakers giving papers will be P. H. Morse, Magnethermic Corp.; R. K. Wuerfel, chief metallurgist and fellow engineer, Westinghouse Electric Corp., Baltimore; Walter E. Jones, manager of the vacuum melted products project at General Electric Co., Detroit; and R. J. Reed, application engineer, The North American Manufacturing Co., will have his paper presented by Norman H. Davies, company president.

Also presenting papers will be Gilbert J. Langenderfer, sales manager, Heat Treat Division, Surface Combustion Corp.; and N. K. Koebel, director of research and manager of Industrial Heat Treating Division, Lindberg Engineering Co.

This program has been arranged by the Public Relations Committee of the I.H.E.A. This committee consists of Elton E. Staples, Chairman, Hevi-Duty Electric Company; Carl P. Bernhardt, Westinghouse Electric Corp.; D. H. Gardner, Sunbeam Corp.; H. M. Heyn, Surface Combustion Corp.; J. B. Carey, A. F. Holden Company; and J. H. Sands, Eclipse Fuel Engineering Company.

Walter H. Holcroft, Executive Vice President of Holcroft and Company, is President of the I.H.E.A. and C. F. Olmstead, President and Treasurer of Lee Wilson Company, is Vice President of the Association.

ENGINEERING & MANUFACTURING SERVICES

Manufacturers with engineering problems or in need of supplementary engineering or drafting talent during peak periods will find a solution in the new, descriptive brochure available from Associated Engineers, Inc., Agawam, Mass.

Founded in 1944, Associated Engineers, Inc. now employs over 800 skilled engineers, designers, draftsmen, technicians, tool makers and machinists in its main offices and plant in Agawam, Mass., and in two branches and three wholly-owned subsidiaries in various parts of the United States.

The brochure explains and illustrates the firm's six basic divisions of Mechanical Engineering, Tool Engineering, the Industrial Laboratory, the Special Services Division (Technical Writing), the

(Continued on page 42)

reduce costs

improve production

Proved in thousands of installations

YOUNG BROTHERS OVENS

Light metal alloy aging and solution heat treating ovens.

● Young Brothers Ovens and Furnaces designed for heat treating requirements are designed and built to improve the quality of the finished product and provide savings in time, fuel and materials. Each one is engineered to meet the specific need regardless of the process, material or product.

The proven dependability of Young Brothers Ovens in thousands of installations during a period of 60 years is your assurance of the finest results at lower overall costs. A wide variety are available for Annealing and Tempering, Drying and Impregnating, Aging, Normalizing, Preheat, Stress Relief, Homogenizing and for other processes.

Write for Bulletin 157

YOUNG BROTHERS COMPANY

1849 Columbus Road Cleveland 13, Ohio

COPPER BRAZING

(*Continued from page 7*)

In the case of straight butt joints, straight wires can be placed along the seam and brazed in a horizontal position.

Foil or strip is used in many cases; sometimes inside the joint when design permits, or by replacing a wire ring as in joining two halves of a sphere as in a float shell.

Slugs are used in special cases for easier assembly such as the furnace brazing of tungsten carbide slugs to steel shanks.

Electro-plating is used in special cases; namely, the Bundy weld double wall tubing process. This is extremely advantageous where the copper plate serves as the meat of a sandwich, as within a sleeve joint. There is a distinct advantage in copper plating where a questionable oxidizing atmosphere is used in furnace brazing.

Molten sprayed copper is a specialized method of application and is expensive.

Copper powder paste is one of the most valuable tools in copper brazing. Its chief advantage is its versatility for application in places where the use of wire or foil forms are not practical. This form is more expensive than rings or wires. However, paste can be used in combination with rings, foils, or slugs to hold them in place. The main disadvantage of paste is the deposit of ash or carbonaceous material on the surface of the assembly and the tendency to oxidize in containers and upon drying.

Controlling the Flow of Copper

To prevent or limit the creep of brazing material, solutions such as chromic acid may be applied to metal surfaces. Flash chromium plating may also be used. Whiting compound, leads, or chalk suspended in water may be used on thread surfaces.

Common fuel oil is not perfect but is practical for small production quantities, if surface cleanliness is not a prime consideration.

Sometimes it may be necessary to remove excess copper flashing from the assembly. This can be accomplished by *controlled* pickling or deplating processes. Further heat treatment in a sodium cyanide salt bath will sometimes work, depending upon the severity of the quench and concentration of cyanide.

Electrolytic sodium cyanide solution of seven to ten percent operated at 120-140°F. will remove excess copper but time is the controlling factor in the amount of copper to be removed.

Atmosphere Used in Copper Furnace Brazing

The electric furnace is usually considered best for furnace brazing; however, gas or oil fired furnaces can be used in connection with retorts, muffle designs, or radiant tube firing. Furnaces used for brazing can be classified into three types; namely, the box-type

(*Continued on page 44*)

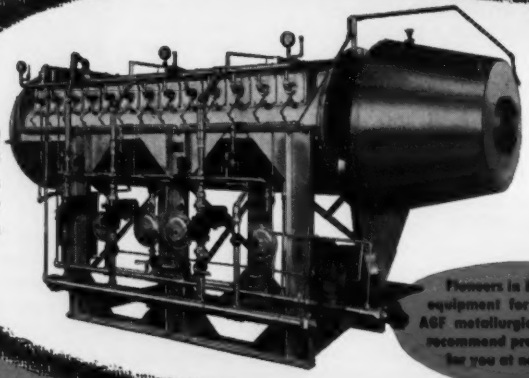
Controlled Atmosphere Heat Treating at the Lowest Unit Cost

Use this continuous production furnace without modification for general and atmosphere work, including "Ni-Carb" ammonia-gas carburizing. Gentle tumbling action mixes the work and assures uniform heat treating.

Here are some of the many engineering improvements AGF Pioneers have made so that you can produce more pounds of work for every dollar invested in an AGF furnace. Less maintenance and operational cost than with any other furnace.

- Automatic self-metering feed hopper reduces work handling costs.
- Better control of processing atmosphere and temperature.
- Improved high production capacity combustion system.
- Increased thermal efficiency because only the work enters and leaves the furnace. Baskets, trays, chains and other troublesome mechanisms are eliminated.
- Alloy life is increased because the alloy remains within the furnace heating chamber at all times.

Improved AGF Continuous Rotary Retort Furnaces



See this furnace at the METAL SHOW Booth No. 726

Pioneers in heat treating equipment for 79 years. Ask AGF metallurgical engineers to recommend proper equipment for you at no obligation.

Sizes in production capacities up to 800 pounds per hour. Representatives in principal cities.

AMERICAN GAS FURNACE CO.

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Send me your Bulletin No. 870 which will help me produce a quality product at lowest cost.

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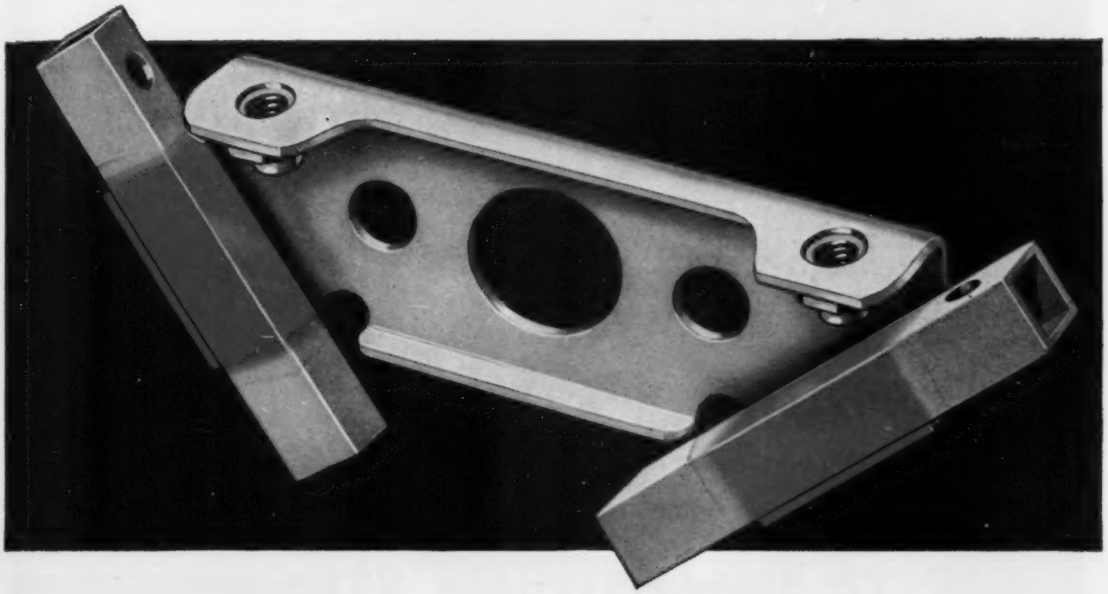
Jack & Heintz Saves $15.84 Per Hour...

with TOCCO® Induction Brazing



Brazing Costs Down—When Jack & Heintz engineers switched from torch brazing to automatic induction, brazing cost of these inverter brush mounts fell from $.05 to $.006 each—a reduction of 83% in direct labor costs alone! Additional savings result because less cleaning is required after TOCCO, and fuel costs are much lower, too.

Brazing Production Up—While costs dropped, production on the part zoomed—from 40 to 360 brazed assemblies per hour. Furthermore, rejects and scrap, formerly high, are now negligible.

Versatility—The part shown is just one of over 25 parts, large and small, which alert J & H engineers have converted from old-fashioned brazing methods to modern, automatic TOCCO. Overall brazing costs (TOCCO brazing versus former methods used) are down 75%—brazing speed, up 100%.

If the manufacture of your product involves brazing, heat-treating, forging or melting of ferrous or non-ferrous metals, don't overlook TOCCO as a sound method of increasing production, improving product quality and slashing costs.

THE OHIO CRANKSHAFT COMPANY

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Please send copy of "Typical Results of TOCCO Induction Brazing and Soldering".

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Faster solution-heat-treating with a Hevi-Duty CONVECTION BOX FURNACE

The Beryllium Corporation uses this Hevi-Duty Multi-Range Convection Box Furnace in their process control laboratory for solution-heat-treating "Berylco", Beryllium Copper alloys. The laboratory director reports outstanding results and economy due to the following advantages:

1. Rapid heating to solution temperatures (1450 or 1700°F depending on the alloy being treated) is made possible by a motor driven fan that circulates the hot gases through the densest of loads, and by,
2. Direct, even heat radiation to all surfaces of the load by Hevi-Duty Return Bend heating elements on all six sides of the furnace chamber.
3. Control of temperature within ±5°, throughout the chamber.
4. Elimination of oxidation by use of a protective atmosphere.
5. Freedom of both hands for rapid charging, discharging and quenching by a foot treadle operated door.

For further information about Hevi-Duty Convection furnaces, write for Bulletin 341R.

HEVI-DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers ***Constant Current Regulators***

NEWS TO HEAT TREATERS

(Continued from page 39)

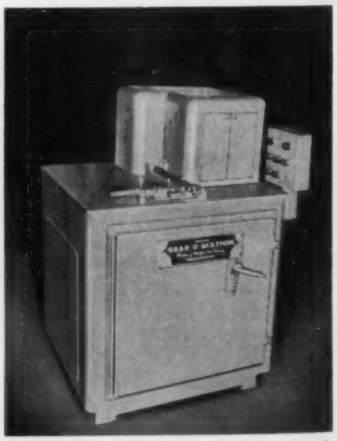
Special Products Division and the large manufacturing plant.

For further information circle No. 6

GEAR SKEW LOADER

Equipment is now available for the automatic skew loading of gears prior to heat treating. It's the new "Skew Loader" as developed by the Gear-O-Mation Division, Michigan Tool Company, Detroit, Michigan. Using the unit, an operator can load 4200 face-oriented gears per hour on to a gear carrier. Although designed expressly for high volume gear heat-treating operations, the skew loader is felt applicable to many other center-bored parts and production methods.

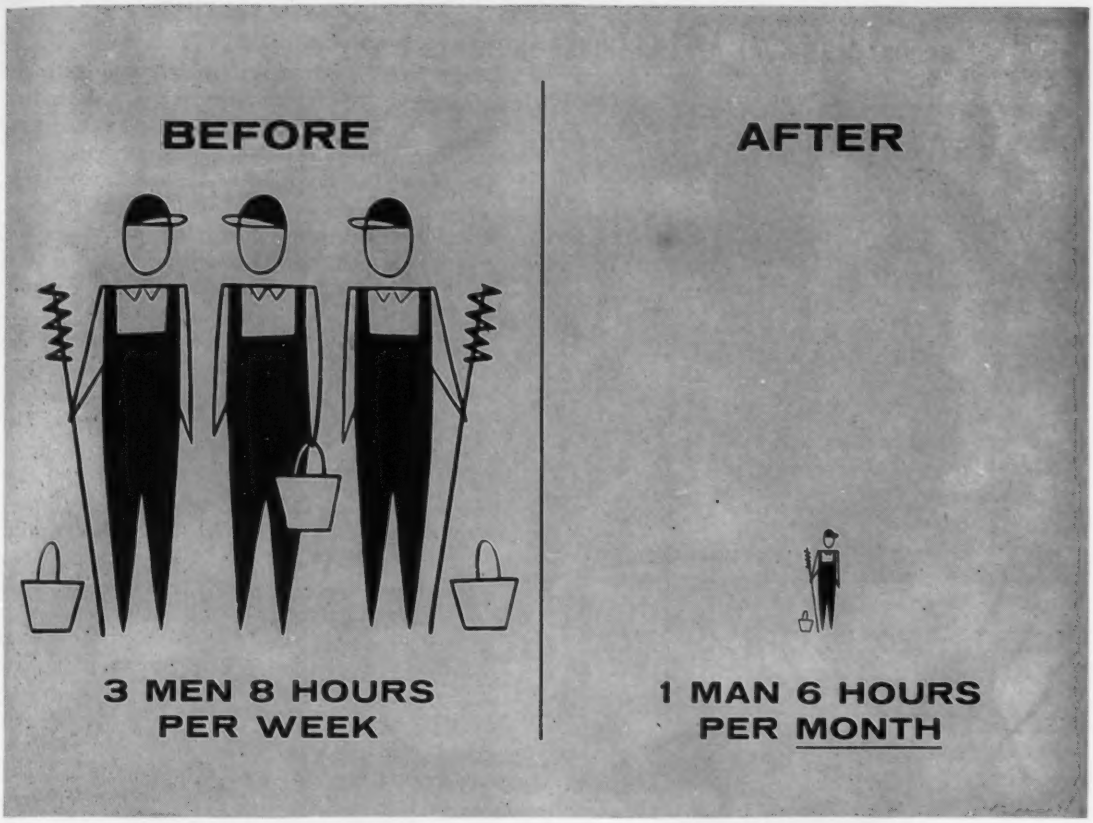
In operation, the gears enter the skew loader through a gravity expandable track and are stopped by an escapement mechanism. From the escapement, gears are fed one at a time into a V-track and are pushed forward by the plunger of an air cylinder actuated by a proximity switch. The air cylinder, returning to neutral, triggers a limit switch-controlled solenoid which releases another gear. This action takes place in split seconds—an average skew load of about 14 gears is readied in less than five seconds.



When a full load is positioned, the operator merely inserts the skew (or rod) through the center-bored holes and lifts the load on to a gear carrier.

For further information circle No. 7

(Continued on page 46)



A switch to Sun Quenching Oil Light resulted in this dramatic reduction in cooler-maintenance man-hours in a major automotive plant.

SWITCH TO SUN QUENCHING OIL LIGHT CUTS COOLER MAINTENANCE BY 94%

After switching to Sun Quenching Oil Light, a leading auto manufacturer reported a *94% reduction in cooler maintenance.* No heavy sludge deposit had formed on cooler coils after 18 months of continuous use. It took *fewer* men *far less time* to clean coolers.

Reason: Sun Quenching Oil Light has natural detergency and solvent action that *keeps cooling systems clean for long periods.*

It's Versatile. Sun Quenching Oil Light can be used in any type of quenching-oil system. It has uniform quenching properties and low drag-out.

It's Economical. Sun Quenching Oil Light can save you money two ways . . . in low initial cost and in reduced maintenance.

For Full Information, call your Sun representative or write to SUN OIL COMPANY, Philadelphia 3, Pa. Dept.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

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NO.5 in a series of ALUMICOAT APPLICATIONS

For HIGH TEMPERATURE APPLICATIONS

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Molten Aluminum PROCESS

CAN PROTECT HEAT TREATING EQUIPMENT FROM CORROSION & HEAT OXIDATION!

The new, ALUMICOAT molten aluminum Process has been perfected to give steels added resistance to corrosion and heat oxidation where continuous high temperatures are a problem.

In the ALUMICOAT Process, heat treating fixtures, trays, etc, are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

The ALUMICOAT Process can give you greater economies through the use of lighter yet more rugged fixtures with a longer life through added resistance to corrosion and heat oxidation!

Send for full details. Your inquiry is invited.

ARTHUR TICKLE ENGINEERING WORKS, INC.

38 Delevan Street MAin 5-4200 Brooklyn, N. Y.

COPPER BRAZING

(*Continued from page 40*)

for batch work, continuous mesh belt, and the roller hearth. Each one has its particular usage dependent upon rate of production, size and weight of the part, cost of equipment, operation, and maintenance.

The main function of an atmosphere is to prevent oxidation, remove previous oxidized areas before reaching brazing temperature, and to protect the assembly from oxidation in cooling.

There are three basic atmospheres used in copper brazing:

1. Exothermic gas is the least expensive and the safest to use. It is quite adequate for all low carbon steels and can be used for alloy steels if decarburization is not a factor in further heat treatment. The dew point of exo gas is normally 10°F. in excess of the temperature of the cooling water used in the condenser of the exothermic generator. In some cases, the application of a high temperature flux such as Amwell 22 can be used with some stainless steels or high chromium base steels to give a successful braze even with exothermic atmosphere.

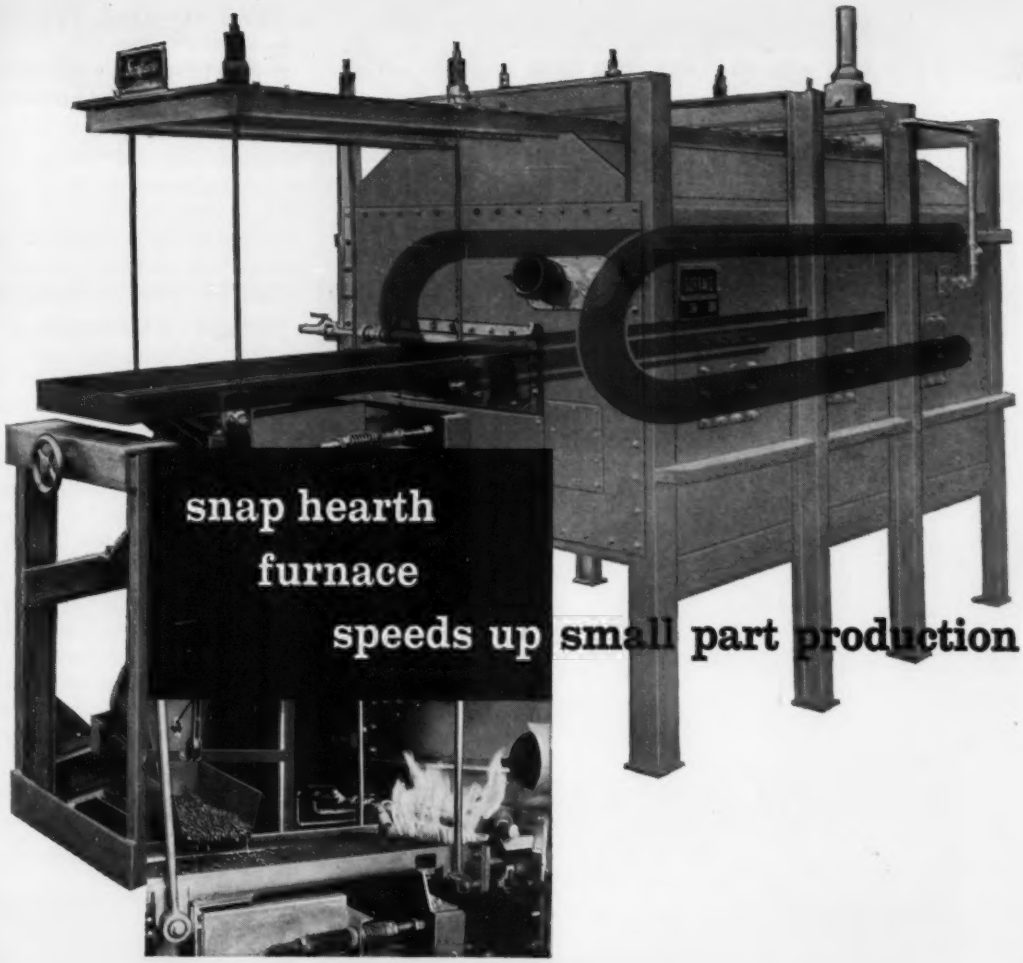
2. Endothermic gas is best used when brazing medium alloy steels, such as 4140, since the dew point or carbon potential of the atmosphere can be controlled easily by the proportion of gas and air entering the generator. The dew point can be varied and closely controlled from –5° to +60°. Endo gas is not quite as safe to use as exothermic due to the higher hydrogen content and will average 5 to 10% higher in cost. Lean endo gas can be used and enriched with raw propane, but extreme care must be maintained to prevent excessive carbon in the atmosphere which is detrimental for good brazing.

3. Hydrogen, thoroughly dried by use of electro dryers, is the most expensive atmosphere. More modern adaptation such as the Baker Nitroneal generator may be used to reduce costs. Among the disadvantages of dry hydrogen are the hazards of explosions and the extra costs in design of the furnace and safety extras. High chromium alloys and stainless steels must be brazed in hydrogen, but it is not a "cure-all" since fluxes must be used in some cases. Nitriding steels present a real problem due to high aluminum content and require use of fluxes even in highly reducing atmospheres. Costs will exceed exo gas by forty to one hundred percent dependent upon the method of generation. Dry hydrogen should be used only in muffled-type furnaces.

Strength of Copper Brazed Parts

Increased strength is one of the main advantages in changing a design to copper brazing. Tests conducted by Messrs. Oswald and Horman of National Cash Register Lab and Mr. G. B. Wilkes of Thompson Lab, General Electric Company, have proved the increased strength in shear of copper brazed joints.

(*Continued on page 55*)



snap hearth furnace speeds up small part production

The quantity and quality of small parts can be increased by controlled atmosphere heating and quenching in this new Surface® Snap Hearth Furnace. Production rates up to 500 lbs/hr are attained in many plants.

This is the first suspended hearth furnace to use suction type radiant tube firing, which eliminates a muffle and its extensive replacement problems. Another important feature is the hearth, which snaps to move the parts a short distance at regulated intervals.

Combined with Surface atmosphere generating equipment, the Snap Hearth Furnace is especially efficient for clean hardening, dry cyaniding, carbon restoration.

Write for Bulletin SC-173.

Surface Combustion Corp., 2381 Dorr St., Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

wherever heat is used in industry

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ROLOCK

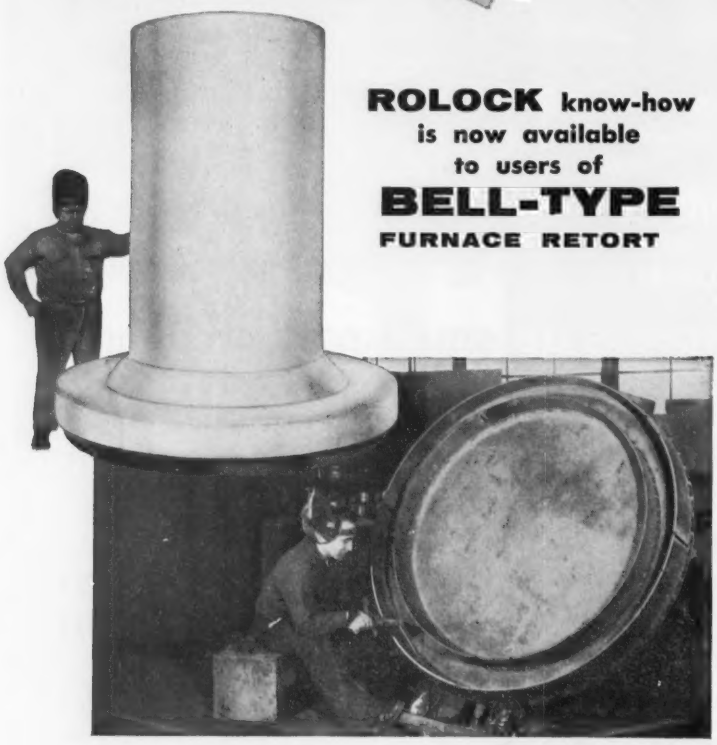
FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

ROLOCK know-how is now available to users of

BELL-TYPE

FURNACE RETORT



On the sound basis of PROVED performance, Rolock has become a major supplier of bell-type furnace retort hoods and bases. Photographs show examples of current production.

Rolock has the modern facilities required to handle these large welded fabrications with assurance of quality workmanship. Rolock engineering has contributed many design improvements, such as the incorporation of alloy in the bases to prevent cracking, and superior methods of reinforcement. Rolock skill in handling high nickel and straight chrome alloys is your promise of long service life. Finally, Rolock quality standards are maintained by any required forms of inspection.

Next time you order equipment of this type, call Rolock. You will not be disappointed.

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ROLOCK INC., 1232 KINGS HIGHWAY, FAIRFIELD, CONNECTICUT

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

6RLS7

NEWS TO HEAT TREATERS

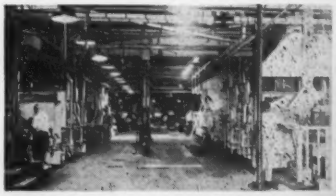
(*Continued from page* 42)

HEAT TREAT LINE FOR AUTOMATED HARDENING

Standard Pressed Steel Co., Jenkintown, Pa., has completed its second automated line for the heat treatment of precision threaded fasteners, raising its automatic heat treating capacity to more than 100,000 screws per hour.

Built, as was the first line, by the Surface Combustion Corp., Toledo, O., around a 30-foot long radiant-tube hardening furnace, the completely automatic line stretches for 110-feet and is serviced by a three-story-high system for air and oil cooling.

Mechanically, the automated giant conveys batch-weighed runs of fasteners through seven stages of carefully timed washing, hardening, quenching, tempering and rust-proofing operations. At the end of the line, the fasteners are ready for packaging and shipment. A complete run takes about two hours, with variations dependent upon the size and type of fastener in each run.



Hardening is carried out in an oxygen-free controlled gas atmosphere that eliminates oxidation, decarburization and sooting of the fasteners under treatment. This produces clean fasteners with a uniform hardness.

The atmosphere inside the hardening furnaces is a mixture prepared in a special gas cracking unit connected to the furnace. Precise control over the carbon potential of the resulting mixture of carbon monoxide, hydrogen and nitrogen allows treated screws to recover small, controlled amounts of carbon that have been lost during processing.

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributors: Bethlehem Steel Export Corporation

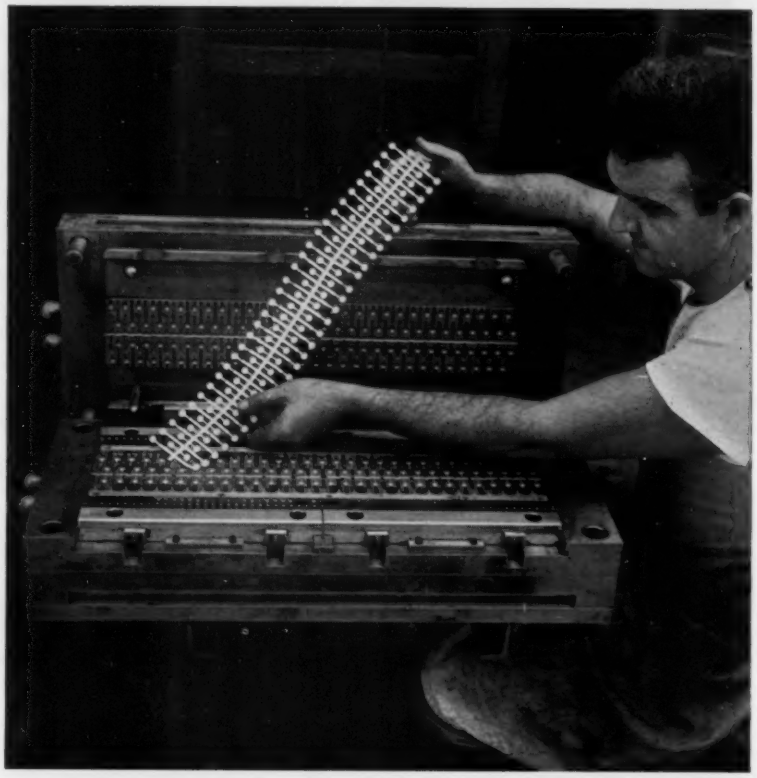
BETHLEHEM TOOL STEEL ENGINEER SAYS:

Air-Quenching Adds to Life of Hot-work Tools

Most hot-work tool steels can be hardened by quenching in oil or air. Because of convenience in handling, and in order to avoid excessive scaling, many hot-work tools are oil-quenched. However, air-quenching is better practice because air-quenched tools have lower residual stresses than tools which have been liquid quenched. Since heat-check failures develop from surface stresses produced in service, the presence of residual stresses in the tool itself can lead to premature failure. Tools with low residual stresses are best suited for long service life on hot-work applications. That's why air-quenching is usually considered the most practical procedure for hot-work tools.

Putting the Bite in Chisel Steel

At Stanley Tool's Atha Plant, Newark, N. J., dies of Bethlehem Lehigh H tool steel are used in trip hammers of this type to forge cold chisel blades. Lehigh H, our special-purpose high-carbon, high-chromium grade, is ideal for this type of application because of its excellent wear-resistance and adequate red hardness.



INJECTION MOLD OF DURAMOLD B

Pops Out Plastic Poppit Beads

This injection mold, containing 120 cavities, is used in an 8-oz injection machine to produce one size of the popular polyethylene Poppit Beads. The mold is made of Bethlehem Duramold B tool steel, and was produced by R. A. Koegl Stamp & Die Works, Hillside, N. J., from steel supplied by Aekerlind Steel Co., Inc., New York.

Duramold B is an oil-hardening, chromium-type of plastic-molding die steel, with an addition of boron. In heat-treatment, it develops a surface hardness of Rockwell C62.

Duramold B is ideal for long service life because of its high core-strength and resistance to wear. Toolmakers are sure to like it because it can be annealed to a hardness of 100 max Brinell, which permits easy cold hobbing, even where deep or large cavities are used.

Typical Analysis

Carbon 0.07	Manganese 0.30
Silicon 0.15	Chromium 1.00
Molybdenum 0.25	Boron added

To order a trial piece of Duramold B, or obtain detailed information about this or any other grade in Bethlehem's complete family of tool steels, simply get in touch with your Bethlehem tool steel distributor.

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AT ± 5° F.

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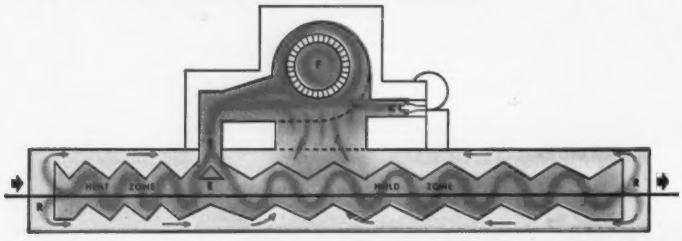
The continuous "Circ-Air" is suitable for heating steel, brass, aluminum and cast iron at temperatures up to 1450° F.



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"Circ-Air" furnaces have been built in widths up to 108 inches, in lengths up to 165 feet, for temperatures from 250 to 1450° F., and capacities from 200 to 16,000 lbs. per hour. *Send for Bulletin 13-A*

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No open flame is exposed inside the hardening furnace. Heat—up to 1600° F.—is supplied by burners placed inside radiant tubes along each side of the furnace. The heat generated by the burners radiates through the metal walls of the burner tubes and raises the temperature inside the hardening enclosure.

Automatic recorder - controllers keep a chart of the conditions of temperature, pressure, fuel flow and rate of movement of screws through the line and automatically shut the line down if a breakdown occurs anywhere in the system.

For further information circle No. 8

ELECTRIC VIBRATING PEN

A new electric vibrating pen that is safe, easy to use and can permanently mark, engrave or etch all metals, ferrous or non-ferrous, has been announced by Newage International, Inc., Jenkintown, Pa. This marking instrument, called the Newage Actograp Pen, produces a short, powerful, continuous arc by means of a magnetic vibrating system, thus enabling the user to etch rapidly and easily the hardest tempered steel, monel metal, brass, copper, aluminum, tungsten, carbide, gold and silver. It is light, small and can be handled like a pen.

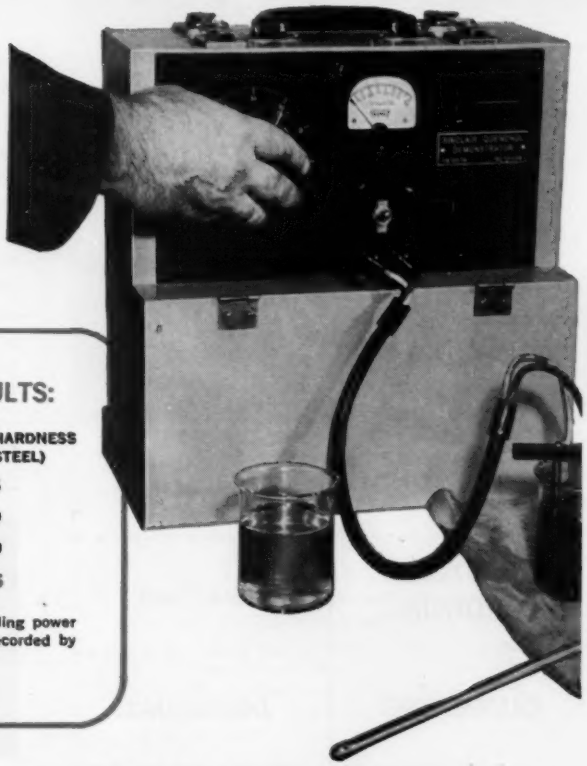
An exclusive selector switch on the transformer permits adjustment of the marking point for etching thick or thin lines to the desired depth. This pen can be used to mark delicate parts or massive sections and the markings can be removed only by grinding or filing the article. The Actograp is al-

(Continued on page 58)

TEST PROVES QUENCHOL'S HIGHER COOLING POWER!

10-MINUTE DEMONSTRATION

Compare any oil you now use with Sinclair QUENCHOL 521 in just 10 minutes! Right in your office or plant, Sinclair's new Quenchol Demonstrator will give you an accurate comparison of relative cooling power . . . show you how QUENCHOL can save money in your quenching operations!



A TYPICAL TEST SHOWS THESE RESULTS:

OILS COMPARED	COOLING POWER*	ROCKWELL C HARDNESS (SAE 1045 STEEL)
Competitive Oil A	576	23.5
Competitive Oil B	729	39.0
Competitive Oil C	1024	41.0
QUENCHOL 521	1369	54.5

*Based on a recognized formula for determining relative cooling power value. Measured as the square of the current (I^2max.) as recorded by Quenchol Demonstrator.

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In numerous production tests, QUENCHOL 521 has demonstrated its far superior quenching ability. All users report better results in the degree, depth, and uniformity of hardnesses obtained. Steels have included SAE 1035, 1040, 4140, etc. In many cases the superior results have been obtained while increasing working loads! Moreover, QUENCHOL's high sludge resistance, low acid formation characteristics and *high quenching reserve* keep it from deteriorating . . . extend QUENCHOL's amazing cooling power with longer service life!

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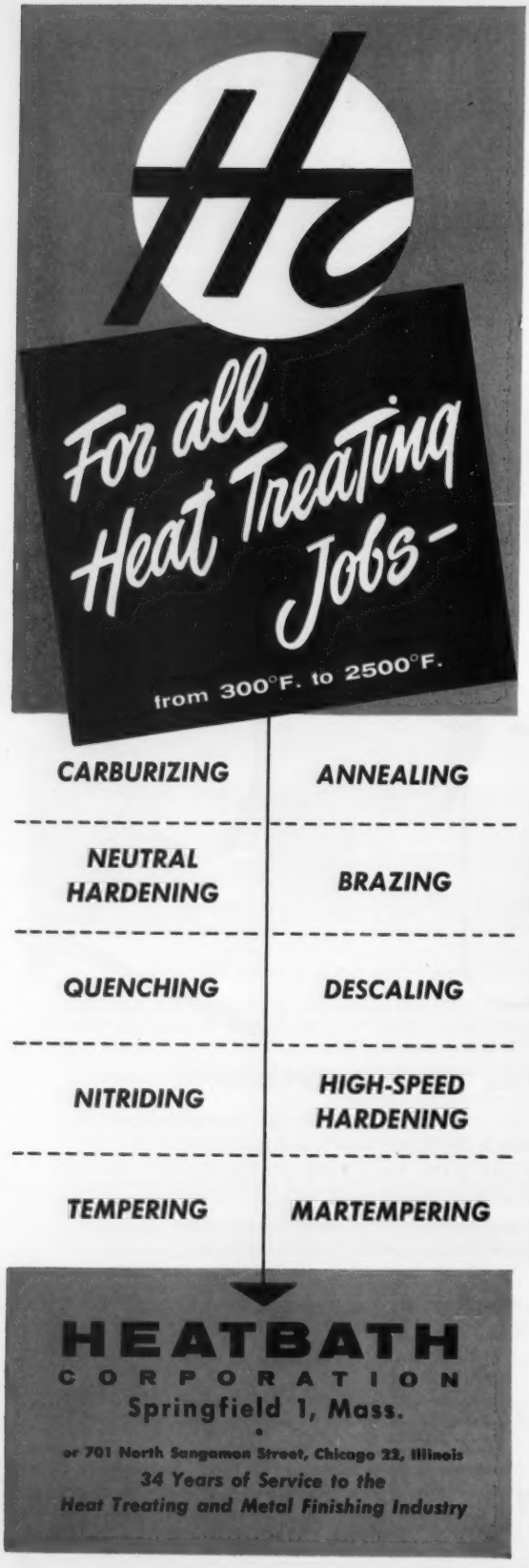

RIGHT OR WRONG

(Continued from page 22)

she'd become competent to do the overall job. After a 3-month trial period doing additional work within the classification, she was demoted.

Mrs. Morrow said it was unfair because she had all the background knowledge needed for the job and could qualify if she were given a chance.

The company pointed out that she had demonstrated basic inadequacy in the knowledge required and had been given a fair chance to make the grade.

Was The Company: RIGHT ☐ WRONG ☐

What Arbitrator Sidney Wolff Ruled:

"Mrs. Morrow, it seems, while performing satisfactorily some portions of the job, made no effort to learn the complexities of the full job. Apparently she was satisfied to do the relatively simple operations. Naturally, by confining herself wholly to this type of work, she became a 'whiz' at it, but becoming an expert in a minor job does not necessarily justify the receipt of a wage rate set for a more difficult job. I am satisfied that Mrs. Morrow has been unable to perform the job. The work she has been doing is but a minor portion of the overall job. The company was not unfair and unjust in downgrading Mrs. Morrow." The grievance was denied. ■■■

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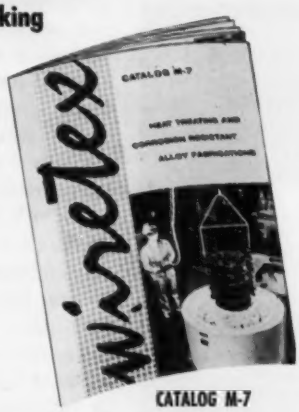

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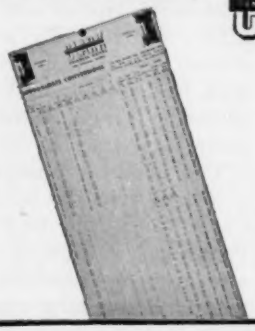

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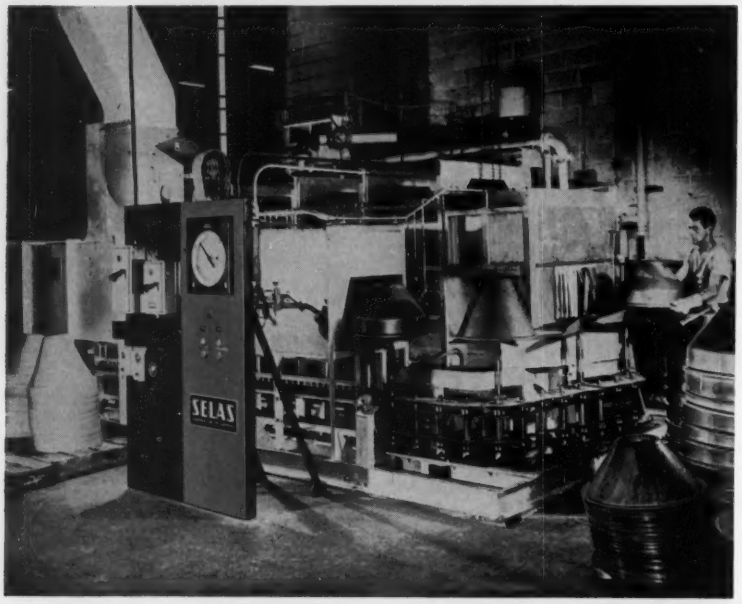
ABSTRACTS



New Selas tunnel annealing furnace provides a continuous, short cycle for annealing work-hardened TV-tube housings made of Type 430-Ti stainless steel.

TUNNEL ANNEALING FOR STAINLESS PARTS

(Source — The Iron Age)

A new, tunnel-type annealing furnace is making it possible for a metalworking plant to switch from a conventional long-cycle anneal to an extra-short cycle requiring only 3 minutes. The material being annealed is a titanium-modified Type 430 stainless. The end product is a spun stainless housing —a cone-shaped affair—intended to contain the innards of a TV picture tube.

The furnace, designed and built by Selas Corp. of America, is now in full-swing production at I-T-E Circuit Breaker Co.'s Special Products Div., Philadelphia.

The need for the annealing cycles stems from the fact that the stainless housings are formed in a series of spinning operations. The spinning (or cold shearing), accomplished on special lathes, is a type of severe cold forming which tends to work harden the steel and markedly reduce its ductility. Annealing serves to restore this ductility for additional forming operations without the risk of brittle breaks in the material.

The housing starts out as a circular plate approximately 21½ in. diameter and 0.125 in. thick. The plate stock, a modified Type 430, is received at the plant in the annealed condition.

The plate is first adequately lubricated and then positioned for forming on a specially built lathe. Spinning is accomplished by forcing the metal progressively over a tool-steel mandrel.

With this type of cold forming, stresses are especially severe. As a result, the chromium-base alloy work hardens considerably. Work hardening lowers ductility to a point where cracking can occur.

Two in-process anneals are required to keep the housing sufficiently ductile for final forming. Previously, a batch-type furnace was used for annealing. While metallurgical results were reason-

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Start heat treating high speed and carbon steels while other furnaces warm up. Powerful burners in this efficient furnace get heat up to 1300°-2350° F. range in minutes. Temperatures accurately and quickly regulated. Ratchet-operated door opens upward — no need to open fully every time. High temperature refractory-lined firebox keeps heat uniform — 7" by 13" by 16½". 200,000 BTU's per hr. Carbofrax hearth, G.E. Motor and Johnson Blower included ..... F.O.B. Factory, $358.00

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ably satisfactory, output was inadequate to meet increasing production requirements.

The new, tunnel-type furnace not only speeds the annealing operations but also makes them continous. The furnace is heated by radiant burners fed with city gas at a 6 to 1 ratio. Furnace temperature is held at about 1700°F.

Housings are fed mechanically to the entrance end of the furnace by rotating paddles. These paddles convey the parts through the 16-ft. length of the furnace, rotating them as they move in order to provide optimum temperature uniformity. Process requires the housings to achieve a temperature of about 1600°F.

In addition to the heating chamber, the Selas set-up also makes provision for air-cooling the parts as they leave the exit end of the furnace. This is accomplished by routing the parts from the furnace to an enclosed cooling tunnel. By the time the parts are conveyed to the end of the cooling tunnel, their temperature is below 350°F.

HOW MEASUREMENTS LEAD TO EFFECTIVE QUENCHING

by Victor Paschkis, Technical Director
and
George Stolz, Jr., Research Engineer
Heat Mass Flow Analyzer Laboratory
Columbia University, New York

(Source — The Iron Age)

Both the type of steel and method of heat treatment must be properly matched to produce a part with a given hardness and other desired mechanical properties. Considering only one aspect of the problem is not likely to result in a successful solution.

In heat treating, a large number of factors can affect the rate of temperature change. This rate, incidentally, is not constant during the quenching operation. It changes greatly with time. All of these factors are interdependent. At any given time, the rates at any point in the part treated depend on all of them.

For purposes of analysis, it is possible to group these variables into two major classes: the internal and the external factors. Internal factors include size, shape, and the material of which the part is made. The material, in turn, can be described in terms of its thermal properties such as thermal conductivity, specific heat, density, heat and range of transformation.

External factors can be summed up in terms of "boundary conductance." This is the rate of heat flow from the surface of a quenched article to the quenching medium.

The internal factors are well understood, although for many steels numerical values are not yet known with desirable accuracy. The subject of boundary conductance, on the other hand, is largely unexplored. A recent test program conducted by the Research laboratories of Columbia University was designed primarily to investigate the lesser known external factors.

The concept underlying the determination of boundary conductance is that such conductance is independent of the material below the surface. As far as the solid is concerned, it is dependent on surface roughness only.

It is possible to determine boundary conductance by using a silver sample. The sample is suspended in a vertical furnace, closed at the bottom during heating. When the sample achieves uniform temperature, the lid is opened and the sample drops at controlled speed into the quench bath.

Temperatures are measured within the sample, since thermocouple wires attached to the surface of the sample would interfere with heat flow and fluid flow patterns in the quench bath. A temperature-time curve within the sample is thus obtained.

Work completed to date includes quenches in still water under a variety of conditions, in agitated water, and in caustic soda.

When quenching in still water, the temperature of the water is very important. At intermediate water temperatures, the vapor film

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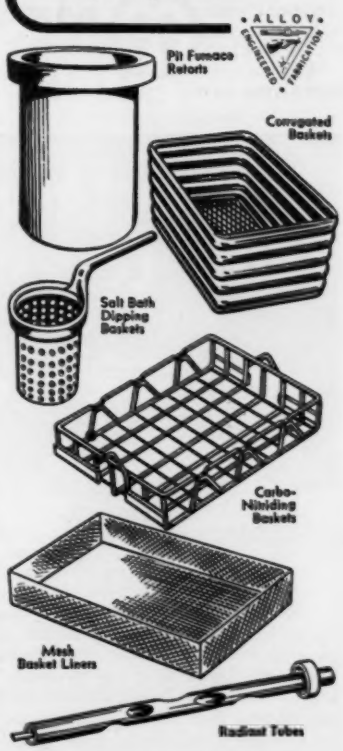

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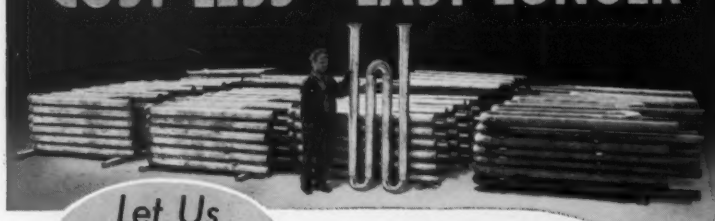

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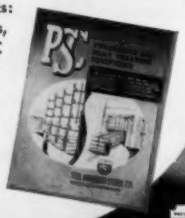
If you are using cast alloy tubes, we can quote you substantially less on our all-sheet alloy tubes. And, with dies on hand for many commonly used sizes of return bends, we can frequently save our customers this important cost. Records of scores of installations show PSC "Thin Wall" tubes are giving much longer service life. For instance, Michigan Malleable Iron Co. reports: "We show an average life of over 3½ years for your fabricated tubes, which is about double our experience with cast alloy tubes". In PSC tubes the return bends are of the same metal and thickness as the legs, promoting uniform flow of gas and minimizing carbon build-up and consequent burn-out. Precision-assembled in any design or dimension. Also sheet-alloy heat-treating retorts and covers, boxes, baskets, fixtures, tubes, etc. We invite your inquiries.



Send for PSC Heat-Treat Catalog 54

THE PRESSED STEEL CO. • Wilkes-Barre, Pa.

breaks down and re-forms repeatedly. At low or high water temperatures, the break of the film is sudden and happens only once.

Extremes of cooling times recorded were 6 seconds for quenching in 40°F water and 66 seconds for quenching in 160°F water.

Another significant variable is the depth of immersion. Here defined as the distance from the water level to the top of the test sphere, cooling rate tends to vary considerably. At a depth of ⅛ in., the cooling time is 37.6 seconds in 110°F water. The temperature drop involved is from 1600° to 250°F.

Changing only the depth of immersion, cooling time required at 2½ in. is 23.6 seconds. At a depth of 5¼ in. cooling time drops to 19.4 seconds.

Velocity of immersion has only a minor effect. Decreasing immersion speed from 42 in./second to 14 in./second results in an increase of cooling time from 23.6 to 26.6 seconds.

The overall size of the quench tank is of great importance. In a large tank, 31 in. x 38 in. and 24 in. deep, cooling required 23.6 seconds. In a smaller cylindrical tank 5.5 in. diam. and 24 in. deep, 39.6 seconds were required. In both cases, the depth of immersion was 2½ in. and the velocity of immersion was 35 in./second.

The increase in cooling time in the smaller tank cannot be explained in terms of an increase in average water temperature. This increase is actually only 8°F, certainly not enough to account for a 65 per cent increase in cooling time. The increase may possibly be explained in terms of a proximity effect of the tank walls.

The most commonly used method of increasing cooling velocity is agitation of the coolant. Another way of increasing cooling speed is the addition of sodium hydroxide to the water.

Accumulation of this kind of information is bound to prove of immediate practical value to the heat treater and metallurgist in solving quenching problems. ■■■

COPPER BRAZING

(Continued from page 44)

Tightness of the joint is a most important factor and, as mentioned before, .001/inch of diameter press fit is best. Properly joined assemblies will test almost equal to the shear strength of the parent metal. In fact, in some cases joints have been found to exceed the parent metal in strength. Another important factor in the strength of a copper brazed joint is the soaking period at temperature. In most brazing operations it is sufficient to allow a short soaking period of one to five minutes after the flowing of the copper; however, for maximum obtainable strength, this soaking time should be increased approximately six fold. Even more important factors in the strength of a joint are cleanliness and the removal of burrs or sharp corners.

Heat Treatment

Almost all copper brazed assemblies can be heat treated after brazing without injury; however, some thought must be given in design to such factors as thermal expansion, transformation changes due to quenching, relative size and positioning of components to prevent excessive stress concentrations in further treatment.

It is well to remember that the most drastic the subsequent heat treatment, the greater the possibility of reduction in strength due to stress concentrations. Cyanide salts are the least desirable as a heating medium with water quenching less desirable than oil quenching. Atmosphere controlled furnaces are the best type of heating mechanism to use for subsequent treatment because surface conditions can be controlled more easily. Strains from quenching can be eased by hot oil or salt quench (martemper or austempering) or even "slack" oil quenching.

Since there will be some enlargement of the grain size due to time and temperature of copper brazing, it would be well to consider normalizing before regular heat treatment when the design of a part requires fine grain sizes after treatment. This normalizing could be combined as a carbon restoration treatment if the original brazing cycle caused decarburization.

Low carbon steels can be carburized before brazing, then cleaned thoroughly to remove excess carbon from surfaces. However, experience indicates that best results are obtained by carburizing after brazing, since any traces of decarburization can be easily corrected. All parts shown in Fig. 1 were heat treated after brazing. The two parts in the center were made of 4140 Steel and after complete treatments showed no effects of decarb. The two outer parts, all low carbon steels, were brazed, carburized, and the sprocket teeth hardened.

In summary, it should be remembered that only general rules can be established for copper brazing and those rules must be modified for each particular case. The field of copper brazing is not limitless but it is certainly an important tool for today's production requirements. ■ ■ ■

Bata cuts mold cleaning time in half with Pangborn Hydro-Finish

Bata Shoe Co., Belcamp, Md., used to clean shoe molds by pickling. For a better cleaning job, Bata replaced this process a year ago with Pangborn Hydro-Finish. Today this machine gives Bata top quality cleaning, does the job *in half the time* required by pickling and has required "no maintenance whatsoever." Also, acid disposal problems have been eliminated.

Says Mr. Albert Kotras, Research, "We thought it was sales talk but the Hydro-Finish has lived up to every claim the Pangborn representative made." Convinced by the performance of its Hydro-Finish machine, Bata management now plans to order a second one.

Today, through new design and use of air jet sluriators, Pangborn Hydro-Finish costs less originally, costs less to maintain and gives you easier handling and added efficiency. Write for Bulletin 1403 to PANGBORN CORP., 3600 Pangborn Blvd., Hagerstown, Md. *Mfrs. of Blast Cleaning and Dust Control Equipment.*

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HEAT TREATING ALUMINUM ALLOYS

(*Continued from page 5*)

hold the temperature at Point 5—1018°F. At this comparatively high temperature, the phenomena we called solid diffusion proceeds at a comparatively rapid rate. This means that the fairly large amounts of copper near the grain boundaries diffuse rapidly inward throughout all portions of the grain so that it is not long before every crystal in the grain contains the same amount of copper—3% in our example. Point 5 can be said to be typical of any point between Point 4 and Point 6 in that anywhere in this range the copper will diffuse throughout the entire structure if the temperature is held for a sufficient period of time. Of course, the diffusion progresses more rapidly at the higher temperatures, which means that a shorter period of time would be required for complete diffusion at those temperatures . . . again emphasizing the importance of time in the heat-treating cycle.

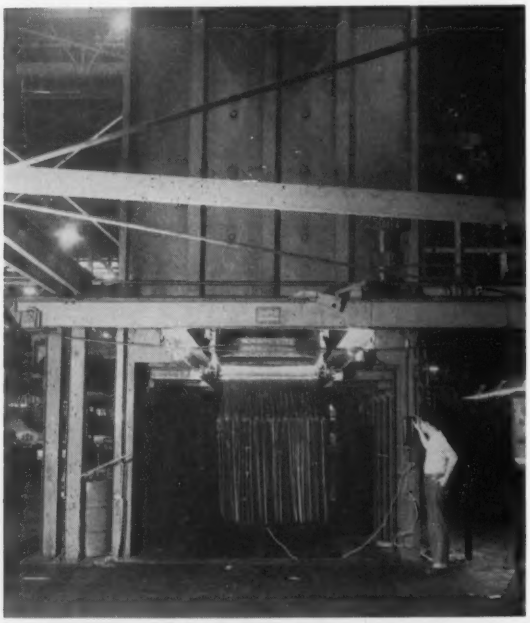

Fig. 5—Close-up showing load of sheets hung on edge ready for lifting into overhead heat-treating furnace chamber. After heating, load will be quenched by dropping into pit of water directly below.

Precipitation

Curve C is the line indicating the beginning of the formation of a compound containing copper and aluminum called copper aluminide ($CuAl_2$). This compound starts to separate or precipitate out of the material at any temperature below Point 6—920°F. for the 3% alloy under consideration. This precipitation of a solid from out of another solid was mentioned previously.

At Point 7 more copper has separated out as copper aluminide. In fact at this temperature (around 850°F.) about 99% of the material is in the form of a copper-aluminum alloy containing 2½% copper, the remainder of the copper being in the copper-aluminide particles which have precipitated out of the copper-aluminum alloy and now exist between crystals and between grains. The other 1% of material is in the form of copper aluminide. This now contains about ½% of the total amount of copper, which of course is still 3% since we have not added or taken away any of the original copper content.

At Point 8 on Chart 2 still more copper has precipitated out in the form of copper alumine.

To develop maximum strength in the aluminum alloys, it is necessary to control carefully the size and distribution of the material precipitated out as it is this material which affords the added strength (due to keying, etc.) as previously explained.

Controls, Quenching

Now let's examine the recommended heat treatments for strengthening the aluminum alloys and see what controls are employed to bring about the proper size and distribution of the precipitated particles.

First step is to bring the aluminum alloy up to the specified temperature, which will lie somewhere between Curve B and Curve C on the constitution diagram for the particular alloy under consideration. A whole series of constitution diagrams for various aluminum alloys will be found in the METALS HANDBOOK. A diagram for aluminum-copper alloys, similar to our Chart 2 can be found there.

Purpose of this first step is to dissolve the precipitated constituents, so they can later be re-precipitated in the form wanted. The material must be held at the specified temperature for a sufficient period of time for this dissolving action to occur throughout all portions of the piece being treated. This maintaining "at temperature" for the specified length of time is called "soaking" and constitutes the second step in the heat-treating cycle.

The third step is to cool the work rapidly by plunging the part into cold water. This is called "quenching". Purpose of suddenly dropping the temperature of the part in this manner is to prevent certain constituents from precipitating out, which they would do if cooled slowly. Here slow cooling would tend to produce a precipitate consisting of large particles instead of the type we want.

Quenching from any particular temperature range tends to retain in the metal the structure present just before quenching. Thus quenching not only prevents the precipitation of certain constituents that we do not want to precipitate at that time, but it also helps control the constituents that we do want out of solution.

The purpose of the entire heat-treating cycle is to develop the right kind of precipitate in the right place in the metal structure. The precipitate we want should be of the "gritty" type rather than the "ball bearing" type, as previously explained, in order to provide the maximum resistance to slippage of crystals. Also the precipitate must be uniformly distributed in extremely minute particles between crystals where it can exert maximum keying effect, rather than outside the grains or along grain boundaries.

Aging

The fast cooling to near room temperature upon quenching produces a "supersaturated" condition where the material has already dissolved in it more of the constituents than it normally can carry in solution at that temperature. Such a condition obviously is unstable. The result is that certain constituents begin to separate out of precipitate from the main mass of the aluminum alloy.

This precipitation occurs at room temperature with many of the aluminum alloys and this action then is known as "natural aging". Certain other alloys must be heated slightly to bring this precipitation to completion within a reasonable length of time. This is called "artificial aging". In either case, this controlled re-precipitation is aimed at providing the correct size, character and distribution of the precipitated particles in the aluminum to produce maximum strength and other desired mechanical properties.

It should be pointed out that aluminum alloys hardened in this manner can be made soft and easily workable again by an annealing treatment. However, annealing alone will not produce maximum workability in aluminum alloys that have been heat treated, for additional cold working and subsequent re-annealing is required in these instances.

Recommended annealing cycles are designed to produce a precipitate in the form of large particles outside the grains along the grain boundaries and not inside between crystals. In this manner, minimum keying effect results and the material is "soft" because the crystals easily slip along their slip planes.

It will be evident from the explanation presented here that it is necessary to follow closely the recommended heat-treating cycles in order to produce maximum mechanical properties in the aluminum alloy. Even slight variations from the recommendations can cause considerable difficulty.

Recommended heat-treating cycles for the various aluminum alloys will be found in the tables accompanying this article. ■ ■ ■

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4. Pittsburgh Instrument and Machine, Brinell test machine, Serial #1118.
5. Cyanide furnace with salt pot; Standard American make—1948. Pot size 24" by 20" equipped with blower, valves, ventilating hood with stack 18" dia. 18 ft. high with Brown indicating control instrument.
6. Flexible mechanical power press 8 ton; make—general; Type #83; Serial #2090, 9" stroke; good condition.
7. Wheelabrator Tumblast; size 36" by 42"; Serial #A48990; make, American Wheelabrator; complete with or without dust collector.
8. Hydroscale for crane or hoist; Model #CH705-30; capacity: 15,000 lbs.; dial diameter 30"; excellent condition, used only 1 month.
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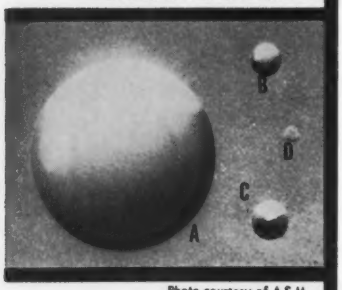

Photo courtesy of A.S.M.

Photograph illustrates the comparative size of impressions made by four different types of hardness tests:

(A) Brinell, (B) Rockwell "B", (C) Rockwell "C", and (D) Scleroscope. Because it covers a larger area, the Brinell impression (A) averages out small inequalities in hardness, surface finish, and complex internal conditions of the metal.

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NEWS TO HEAT TREATERS

(*Continued from page 48*)

ways ready for use—no special preparations are required. It does not heat up excessively and is absolutely safe, for the current is reduced by a specially designed transformer to 2-7 volts. The pen point, which is made of a special alloy that has extremely long life, can be resharpened many times by means of a smooth file.

For further information circle No. 9

DOW FURNACE ADVANCEMENTS

L. E. Cosner, President of Dow Furnace Co., Detroit, Michigan announced three new appointments in the organization. James N. Erle, Jr. is named Sales Manager, Henry G. Wille, Chief Engineer and William J. Suvanto, Service Manager. The company specializes in the design and manufacture of controlled atmosphere heat treating furnaces.

WEATHERPROOF RECORDING GAUGES

Recording gauges for pressure, vacuum, and water or liquid level measurements are now available in new weatherproof cases, according to a recent announcement by The Bristol Company of Waterbury, Connecticut.

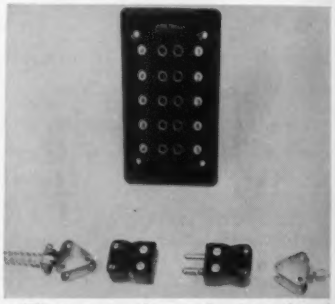
The new gauges are designed for wall or pole mounting outdoors, where it will be subjected to all types of weather. Measurements of water depths or other liquids can be accomplished with float-type, pressure-type, differential-pressure-type, or bubbler-type liquid level gauges; pressure gauges are offered in all ranges.

Both 8-inch and 12-inch round chart models are available in the new cases; flowmeters and thermometers are also offered.

For further information circle No. 10

FASTER THERMOCOUPLE CONNECTIONS

A new line of plug-in thermocouple components designed to simplify and speed up connection of thermocouples to industrial instruments, has been introduced by Minneapolis-Honeywell's Industrial Division.



The connecting units (a series of plugs, jacks, multiple jack panels and such related hardware as cable clamps and tube connectors) can be used for either single or multiple thermocouple connections. The "contact inserts" are manufactured of compensating materials suitable for use with thermocouple types, J. E. T. S. and R. One contact is always slightly larger than the other to prevent improperly polarized connections.

Each connector component has the thermocouple type etched on a disk on its body for quick identification. The new units will be marketed under the name "Quick-Konnect" thermocouple components.

For further information circle No. 11

RADIANT-TUBE FURNACE

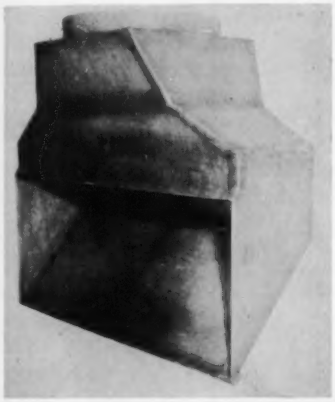
Salem-Brosius, Inc., Pittsburgh, Pa., announced that Kaiser Aluminum & Chemical Corp. has placed an order for a large roller hearth type furnace for installation at Kaiser Aluminum's new rolling mill in Ravenswood, W. Va.

The furnace measures 413 feet in length, with spray quench and the charge-discharge tables. It is a radiant-tube, convection heated furnace for heat treating aluminum alloy plate. A similar furnace is being installed by Salem-Brosius at Kaiser Aluminum's Spokane (Wash.) Plant.

For further information circle No. 12

CORROSION-RESISTANT FUME HOODS

This lightweight corrosion resistant fume hood recently introduced by the Haveg Industries, Inc. of Wilmington, Delaware, is one of a large line of standard and custom built corrosion-resistant hoods, fume ducts and stacks made of polyester glass plastic. Among the



advantages claimed for this material are lightweight, high-impact strength, and a very high corrosion resistance to hydrochloric acid and other fumes normally corrosive to other materials. The ease of field fabrication, both for initial construction and possible changes, makes the polyester resin glass reinforced hoods especially suitable for industrial fume removal applications.

It is claimed that both initial material cost and installation and maintenance cost are substantially lower than for materials that will offer comparable corrosion resistance.

For further information circle No. 13

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(*Continued from page 14*)

in Fig. 6 by vertical dashed lines. Note that all maximum points for all tempers within this range occur at 625°F. or 650°F.

Fig. 7 indicates the maximum tensile strength obtained for the optimum aging time at each precipitation-hardening temperature. In the case of solution-treated (A) strip, maximum strength was apparently not reached in the maximum aging time of 8 hours. Table II lists tensile and hardness values resulting from the time needed to produce approximately maximum strength at each temperature.

It has been previously demonstrated that the optimum aging time of 2 to 3 hours is obtained for all tempers at either 625°F. and 650°F. Therefore vertical dashed lines indicating these temperatures are shown in Fig. 7. By comparing for each temper the portion of the curve within the vertical dashed lines for both Figs. 6 and 7, the following optimum heat treatments for Lot 189 are apparent:

Temper	*Treatment*
A	3 hr. at 650°F.
¼H	3 hr. at 625°F.
½H	2 hr. at 625°F.
H	2 hr. at 625°F.

The superiority of the aging treatments suggested

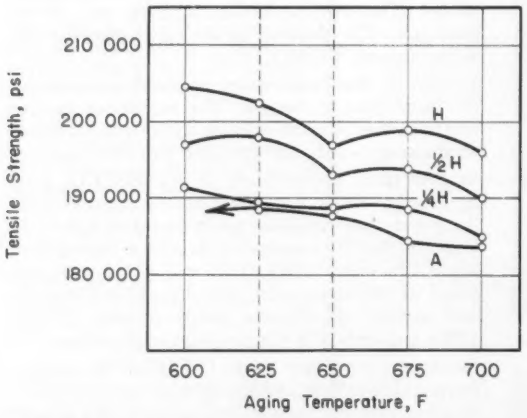

Fig. 7—Maximum Tensile Strengths Obtained From Optimum Aging Times for Various Temperatures. Lot 189 (1.89 per cent beryllium), solution-treated (A), quarter-hard (¼H), half-hard (½H), and hard (H).

above are illustrated clearly in Table III. This table affords a comparison with the standard (600°F.) treatments given in ASTM Specification B 194, which are almost universally employed. For all tempers the new aging times and temperatures prove advantageous, while for some tempers the standard (600°F.) treatment even produced a marked degree of underaging.

To determine the suitability of the proposed new aging treatments for other compositions, additional hardness response curves were developed for Lots 167, 175, 182 and 189. These relationships are presented for all tempers at 600°F., 625°F., and 650°F., in Figs. 8, 9, 10, and 11. The resulting optimum heat treatments are summarized in Table IV, and it will be observed that the suggested times and temperatures apply with one exception (Lot 167, ½H).

Effect of Strip Thickness

Mention has already been made of certain difficulties attending superficial hardness results. A lack of sensitivity has been cited, in that marked variations in tensile values were not always accompanied by similar variations in hardness. Another factor has also been observed, since hardness data were found to be dependent upon stock thickness.

As a means of studying the role of thickness, two small coils of Lot 189 were cold rolled from 0.090 in. to 0.050 in. and 0.040 in. Following solution treating

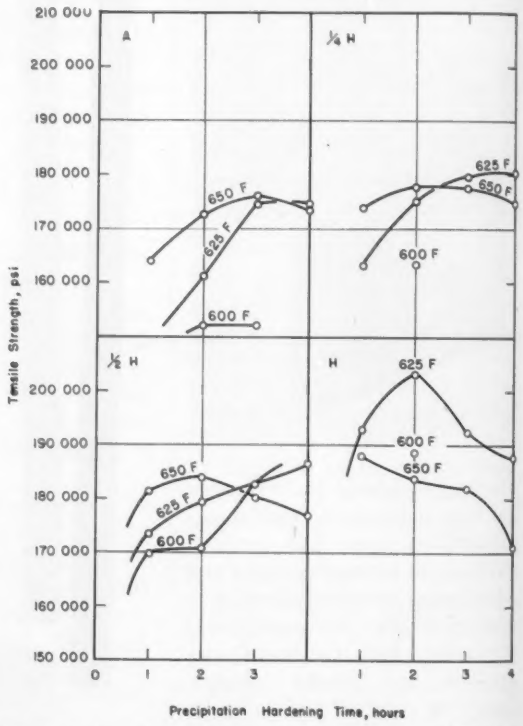

Fig. 8—Hardness Response Curves for Lot 167 (1.67 Per Cent Beryllium.)

at these thicknesses, the coils were further rolled with 50 per cent cold reductions between solution treatments to 0.0043 in. Tension and hardness tests were conducted for each temper and thickness, both prior to and after precipitation hardening for 2 hours at 600°F.

This rolling series has produced a number of test specimens of different thickness for each temper. For example, half-hard (½H) strip was obtained approximately 0.040, 0.032, 0.020, 0.016, 0.010, 0.008 and

TABLE II.—TENSILE AND HARDNESS VALUES RESULTING FROM OPTIMUM AGING TIME AT VARIOUS TEMPERATURES.

Aging Temperature, deg Fahr	Aging Time	Tensile Strength, psi	Superficial Hardness		Aging Time	Tensile Strength, psi	Superficial Hardness	
			15-kg load	30-kg load			15-kg load	30-kg load
	Solution Treated (0.0255 in. thick)				Quarter Hard (0.0230 in. thick)			
Unaged	...	69 400	15T 74.5	30T 48	...	81 300	15T 87	30T 69
600	8 hr	180 000	15N 82.5	30N 63	6 hr	191 300	15N 83	30N 63
625	5 hr	189 000	15N 82.5	30N 63	3 hr	189 500	15N 83	30N 63.5
650	3 hr	188 000	15N 82	30N 62	2 hr	188 500	15N 82.5	30N 63.5
675	75 min	185 500	15N 82.5	30N 63	75 min	188 500	15N 82.5	30N 63
700	30 min	184 000	15N 82	30N 62	30 min	185 000	15N 82	30N 62
	Half Hard (0.0200 in. thick)				Hard (0.0162 in. thick)			
Unaged	...	91 600	15T 90.5	30T 76	...	106 400	15T 92	30T 80.5
600	5 hr	197 000	15N 82.5	30N 63	4 hr	204 500	15N 82.5	30N 62.5
625	2½ hr	198 000	15N 83	30N 63.5	2 hr	202 500	15N 83	30N 64
650	75 min	193 000	15N 83	30N 64	1 hr	197 000	15N 82	30N 62
675	30 min	194 000	15N 82.5	30N 63	25 min	199 000	15N 82	30N 62
700	25 min	190 000	15N 82	30N 62	15 min	196 000	15N 82	30N 62

TABLE III.—SEVERAL AGING TREATMENTS COMPARED.

		Temper			
		Solution Treated	Quarter Hard	Half Hard	Hard
Recommended heat treatment resulting from present investigation	Heat treatment	3 hr 650 F	3 hr 625 F	2 hr 625 F	2 hr 625 F
	Tensile strength, psi	188 000	189 500	198 000	202 500
	Superficial hardness:				
	15N	82	83	83	83
	30N	62	63.5	64	64
According to ASTM Specification B 194 – 55	Heat treatment	3 hr 600 F	2½ hr 600 F	2 hr 600 F	2 hr 600 F
	Tensile strength, psi	160 000 to 190 000	170 000 to 200 000	180 000 to 210 000	185 000 to 215 000
	Superficial hardness:				
	30N	55 to 61	57 to 63	59 to 65	60 to 66
Values from present investigation resulting from heat treatment prescribed in ASTM Specification B 194 – 55	Heat treatment	3 hr 600 F	2½ hr 600 F	2 hr 600 F	2 hr 600 F
	Tensile strength psi	174 000	184 300	192 500	199 000
	Superficial hardness:				
	15N	82.5	81.5	82	82.5
	30N	62.5	61.5	62	62.5

0.005 in. thick. Since each thickness was produced from the same lot of material, given equivalent breakdown and temper reductions, and solution treated continuously through the same furnace at a speed selected for 0.015 to 0.020-mm grain size, the resulting products should be similar except for thickness.

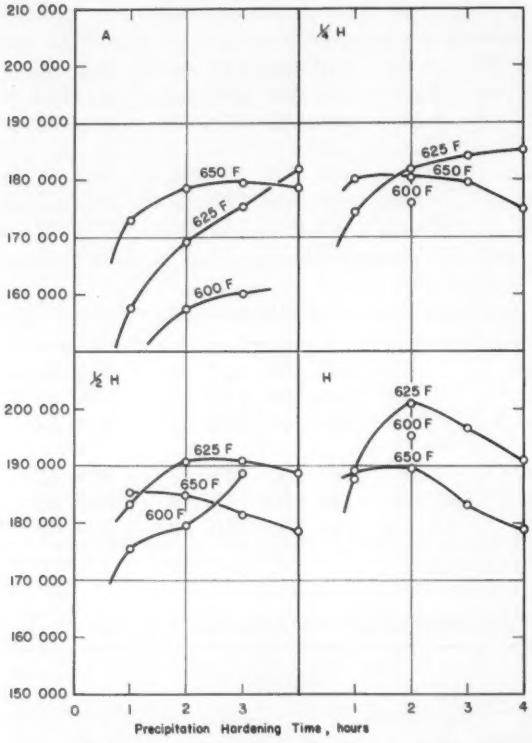

Fig. 9—Hardness Response Curves for Lot 175 (1.75 Per Cent Beryllium.)

Fig. 12 shows the influence of stock thickness upon the mechanical properties for half-hard (½H) and age hardened (½HT) conditions. In both cases, tensile strength increases with a decrease in thickness. The pattern of the hardness curves is somewhat surprising, in that a sudden drop occurs at thicknesses below 0.020 in., followed by a subsequent rise under 0.010 in. This increase is probably due to the hardness of the anvil of the testing machine. Since the sharp drop in hardness around 0.010 in. is accompanied by a gradual improvement in tensile strength, reliance upon hardness values below 0.018 in. or 0.020 in. thick may lead to incorrect assumptions.

Reference to Fig. 13 will indicate another anomalous condition of hardness testing. In this instance, superficial hardness and tensile strength are plotted against beryllium content for solution-treated (A) strip. As anticipated, there is a gradual improvement in both strength and hardness with increasing beryl-

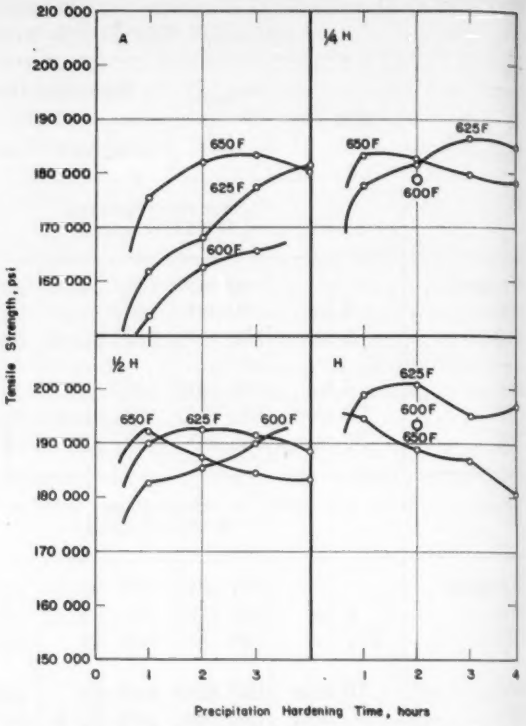

Fig. 10—Hardness Response Curves for Lot 182 (1.82 Per Cent Beryllium.)

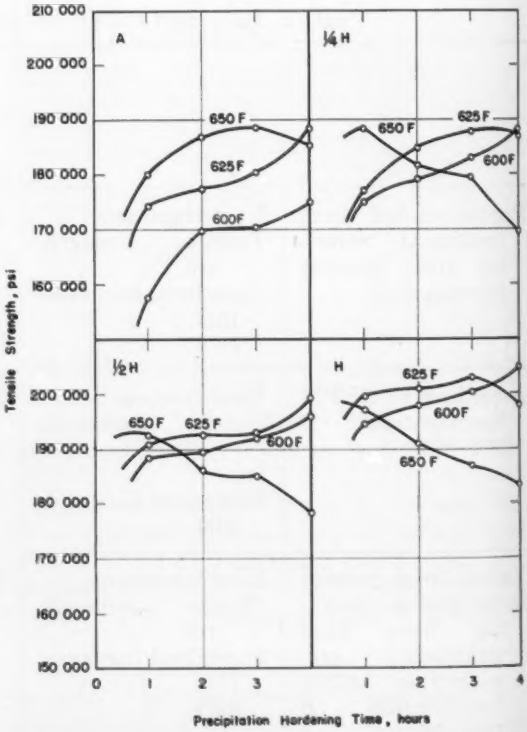

Fig. 11—Hardness Response Curves for Lot 189 (1.89 Per Cent Beryllium.)

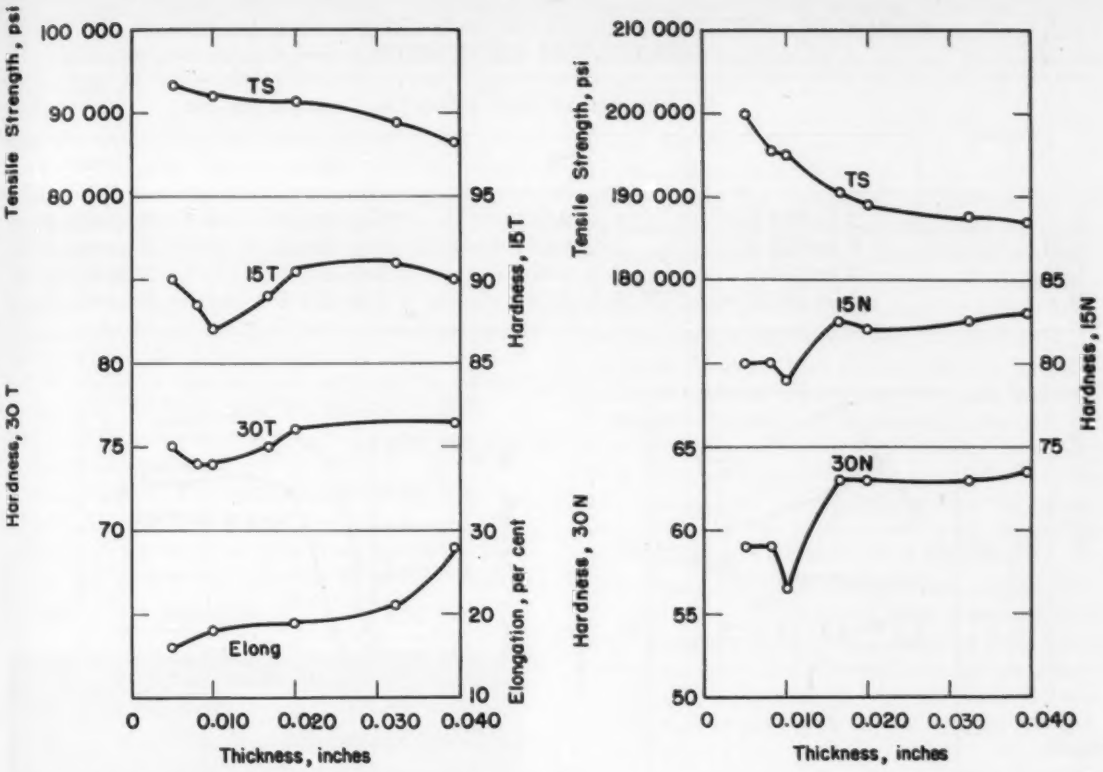

Fig. 12—Effect of Stock Thickness Upon Mechanical Properties of Beryllium Copper Strip in Half-Hard (½H) and Age-Hardened (½HT) Conditions. Lot 189 (1.89 per cent beryllium), with 0.015-mm grain size.

lium content. Size effects between 0.012 in. and 0.025 in. thick strip are negligible for tensile strength, but considerable in the case of hardness. Because the degree of penetration will be greater for soft strip, "anvil effect" should occur in heavier gauges, as compared with half-hard (½H) material. If this assumption is correct, a greater discrepancy for thickness would be expected with the 30T than 15T scale on account of the heavier load, hence deeper penetration.

Fig. 14, which indicates the relationship between mechanical properties and aging time at 700°F. for half-hard (½H) strip, reveals a trend similar to that shown in Fig. 12. In spite of higher tensile strength, thinner strip (0.010 in.) has a much lower hardness than heavier material (0.020 in.). Once again it is apparent that anvil hardness is not a factor for half-hard (½H) strip at 0.010 in., but may affect the hardness of thinner or softer material. Lack of sensitivity of the hardness test is also demonstrated, in that the increase in tensile strength from 190,000 psi to 203,000 psi between 10 and 30 minutes is not accompanied by a hardness increase.

Effect of Boundary Precipitate

In the course of exploratory work on solution treating to produce desired grain sizes, several lots of strip were produced that exhibited excessive grain boundary

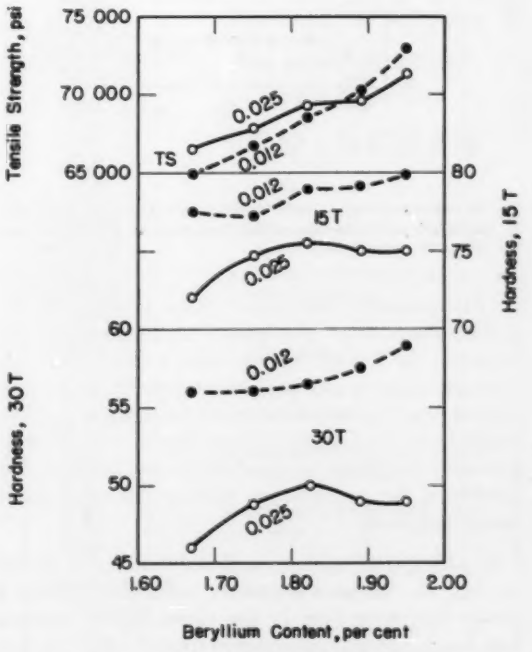

Fig. 13—Influence of Beryllium Content Upon Mechanical Properties of Solution Treated (A) Strip 0.012 in. and 0.025 in. Thick. Grain size, 0.015 mm.

TABLE IV.—OPTIMUM HEAT TREATMENTS FOR VARIOUS BERYLLIUM CONTENTS.

Temper	Lot Numbers and Nominal Beryllium Contents, per cent			
	1.67	1.75	1.82	1.89
A	3 hr 650 F	3 hr 650 F	3 hr 650 F	3 hr 650 F
¼H	3 hr 625 F	3 hr 625 F	3 hr 625 F	3 hr 625 F
½H	2 hr 650 F	2 hr 625 F	2 hr 625 F	2 hr 625 F
H	2 hr 625 F	2 hr 625 F	2 hr 625 F	2 hr 625 F

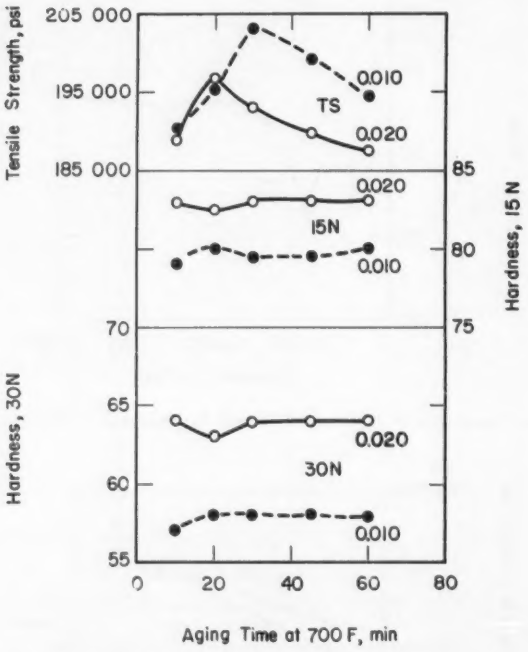

Fig. 14—Effects of Aging Times at 700°F and Strip Thickness (0.010 in. and 0.020 in.) Upon Mechanical Properties of Half-Hard Strip. Lot 195 (1.95 per cent beryllium.)

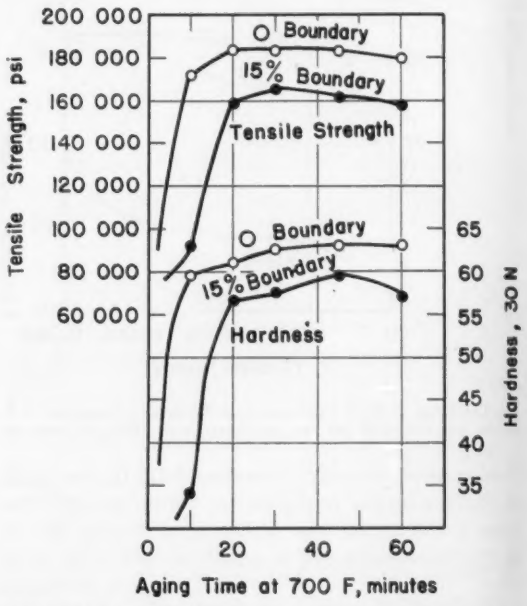

Fig. 15—Influence of Grain Boundary Precipitate Upon the Aging Characteristics of Solution-Treated Strip 0.025 in. Thick. Lot 195 (1.95 per cent beryllium).

or intergranular precipitate. This product is the gamma phase which precipitates initially at the grain boundary as a result of too slow a quenching rate from the solution-treating temperature. Residual precipitate may be left at the grain boundaries through insufficient solution time or too low a solution temperature. Beryllium in this form is not available for hardening by precipitation during the subsequent aging treatment.

In addition to lower strength and hardness as shown in Fig. 15, excessive boundary precipitate causes a slower hardening rate. It also causes higher strength and lower ductility in solution-treated strip, so that this material has decreased formability prior to aging. This may be a distinct disadvantage for applications requiring severe forming such as deep drawing. ■ ■ ■

Editor's Note: *This article has been extracted from a paper presented at the Second Pacific Area National Meeting of the American Society for Testing Materials with permission of the Society. The paper will be one of a group published in ASTM Special Technical Publication 196, "Papers on Metals, 1956."*

HARDNESS TESTING

(Continued from page 20)

Occasionally it is important to the customer that every piece be tested for hardness on a 100% basis. Production testing equipment is available for this purpose, usually operated hydraulically rather than with dead weights. These machines come in various sizes and shapes depending upon the requirements of the particular plant or of the particular job. One of the fastest types of production Brinell hardness testers is illustrated in Fig. 2. This machine employs three colored lights which can be set to indicate a range of hardness, using green to designate pieces falling within the desired range, and using red and yellow lights to indicate "too soft" or "too hard" respectively. Some of these machines are capable of handling as many as eight hundred pieces per hour under ideal conditions.

There are several considerations which must be taken into account in performing Brinell tests. Most of these are set forth in engineering handbooks, and in the Standards of the American Society for Testing Materials. Some are listed, briefly, as follows:

Fig. 2—Production model Brinell hardness tester for testing within a range on an "every piece" basis. Three signal lights, located on top of an electric control panel, indicate relative hardness of pieces being tested. *Photo courtesy Steel City Testing Machines, Inc.*

In testing ferrous metals, the most common load is 3000 kilograms. This is usually held for a period of fifteen seconds. In testing non-ferrous metals, a 500 kilogram load is most common and it is recommended that this load be held for thirty seconds to insure a permanent set in the metal. The A.S.T.M. now recognizes a 1500 kilogram load for use on material in a range of approximately 80 to 160 BHN. The holding time would depend on the nature of the material.

There are three types of Brinell balls commonly in use, and their selection is influenced by the approximate hardness of the material being tested. Standard steel balls are satisfactory on material up to approximately 450 BHN. An extra hard steel ball, commonly known as the Hultgren ball, is recommended up to 500 BHN. Tungsten Carbide balls should be used up to 630 BHN, and the Brinell hardness test is not recommended over this hardness.

Definite standards have been established as to the minimum thickness of material which can be tested by the Brinell method. If a specimen is too thin, the impression tends to go through it and the result is, in effect, a test of the anvil beneath the specimen. Here again, tables have been published, but the overall range is from ¼ inch down to about .075", depending upon the load and the hardness of the material.

In summing up, it should be mentioned that modern quality control techniques have eliminated, to a great extent, the need for inspection of every piece. Depending upon the processes and the customers' requirements 5 per cent, 10 per cent, or 25 per cent inspection is usually sufficient for adequate control. ■■■

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SELAS CORPORATION OF AMERICA DRESHER, PENNSYLVANIA — *Heat and Fluid Processing Engineers* — DEVELOPMENT • DESIGN • CONSTRUCTION

TEMPERING OF STEEL

(Continued from page 18)

UB 46 (SAE 01)

Size: 3/4"ϕ × .1575"

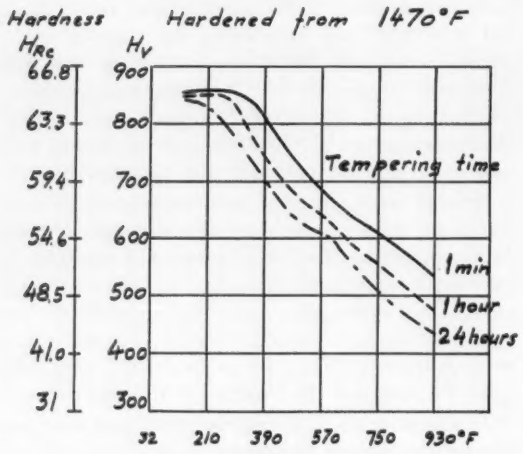

Fig. 11

and higher, however, the hardness gradually decreases as the tempering time increases.

The decrease of hardness is more rapid at the beginning of the tempering. Thereafter, the hardness decreases more and more slowly and reaches a nearly constant value for all temperatures after about 30 minutes (see graph 7).

"THAT REMINDS ME,-I MUST SHOW YOU OUR NEW, DROP BOTTOM FURNACE."

UB 151 (SAE A2)

Size: 3/4"ϕ × .1575"

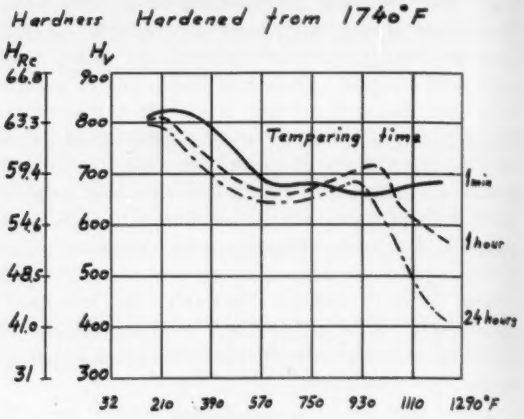

Fig. 12

If the tempering time is set out logarithmically, (see graphs 1-9), a straight linear connection between decreasing hardness and increasing tempering time is obtained. Diversion from the straight line can be found where the unalloyed steels are concerned but is more noticeable with the low alloyed steels such as UHB-46 (SAE 01).

The gradient in the logarithmic curves in the unalloyed steels is about the same at all investigated temperatures for one and the same steel. With increasing carbon content, the gradient rises up to about .70% carbon. Above this carbon content the gradient is almost independent of the carbon content.

TRI-VAN (SAE D3)

Size: 3/4"ϕ × .1575"

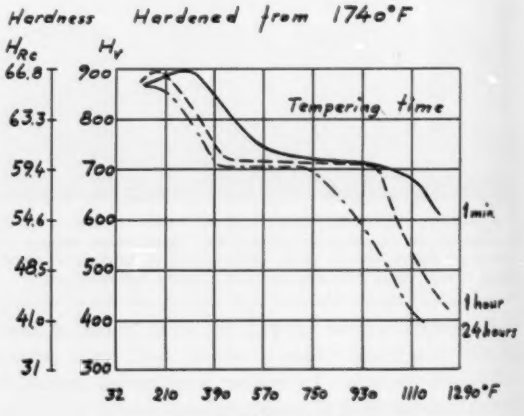

Fig. 13

The hardness curves for the low alloyed steel UHB-46 become flatter at increasing time for tempering temperatures up to 570°F and fall again at higher temperatures.

High alloyed tool steels such as UHB-151 and TRI-VAN react in the same way as the low alloyed UHB-46 when temperatures up to 570-750°F are concerned.

These steels also show a flat portion at about 570°F in the curve showing the hardness relating to the tempering temperature at a constant tempering time. At higher tempering temperatures, namely 930-1020°F, th hardness, however, rises to a maximum when increasing the tempering time. (See graphs 12 and 13).

Among the steels investigated, the following are of most general interest.

UDDEHOLM. BRAND NAME	SAE NO.	ANALYSIS (in%) C.	Mn.	Si.	Cr.	W.	Mo.	V.
UHB 3	a/1015	.15	.70	.25	–	–	–	–
UHB 7	a/1035	.35	.35	.20	–	–	–	–
UHB 14	a/1070	.70	.35	.20	–	–	–	–
UHB 22	–	1.10	.55	.20	–	–	–	–
UHB 25 C	–	1.25	.35	.20	.17	–	–	–
UHB WATER	W1	1.05	.30	.25	–	–	–	–
UHB 46	O1	.90	1.20	.35	.50	.50	–	.15
UHB–151	A2	1.00	.60	.25	5.25	–	1.10	.20
TRI–VAN	D3	2.05	.70	.30	11.50	–	–	.60

a/ Chemical composition not strictly in accordance with SAE specification.

Before tempering, the samples were hardened at the usual temperatures for the respective analyses with a heating time of about 10 minutes.

Tempering was done at various temperatures as shown in the following table:

BRAND	TEMPERATURES DEGREES FAHRENHEIT 210	300 390	480 570	750 930	975 1020	1110	TEMPERING TIME	Heating Medium Oil = O Salt = S Lead = L
UHB 25 C		X	X	X			1, 2, 5, 10, 20, 40 & 60 min.	S
UHB 3		X		X		X	10, 100, 1000 & 10,000 sec.	S 390° - 750° L 1110°
UHB 7		X		X		X	10, 100, 1000 & 10,000 sec.	S 390° - 750° L 1110°
UHB 14		X		X		X	10, 100, 1000 & 10,000 sec.	S 390° - 750° L 1110°
UHB 22		X		X		X	10, 100, 1000 & 10,000 sec.	S 390° - 750° L 1110°
UHB-WATER	X	X X	X X	X X			1, 4, 7½, 15 & 30 min. 1, 3, 6, 12, & 24 hours.	O 210° - 300° S 390° - 930°
UHB-46	X	X X	X X	X X			1, 4, 7½, 15 & 30 min. 1, 3, 6, 12, & 24 hours.	O 210° - 300° S 390° - 930°
UHB-151	X	X X	X X	X X	X X	X	1, 4, 7½, 15 & 30 min. 1, 3, 6, 12, & 24 hours.	O 210° - 300° S 390° - 930° L 975° 1110°
TRI-VAN	X	X X	X X	X X	X X	X	1, 4, 7½, 15 & 30 min. 1, 3, 6, 12, & 24 hours.	O 210° - 300° S 390° - 930° L 975° 1110°

After tempering, the samples were cooled in water.

MANUFACTURERS' LITERATURE

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HEAT TREATING TECHNIQUES

Two new case history reports, "Leaded Steel Shafts Carburized—Then Hardened—in Same Ipsen Furnace" and "Beryllium Copper Parts Precipitation Hardened in Ipsen Draw Furnaces" are included in the latest issue of "Ipsenlab," a periodical devoted to reporting new heat treating techniques and applications. Each case history gives detailed process data including type of treatment, load description, cycle, atmosphere, and type of quench.

The two-page report also describes a new laboratory-size endothermic atmosphere generator especially suited for small volume heat treatment jobs often required in laboratory or tool room heat treating departments, as well as standard self-contained, automatic loading and unloading mechanisms which convert Ipsen manually operated furnaces to semi- or fully-automatic operation.

For further information circle No. 14

RESEARCH ON STEELS

Two reports of research on steels sponsored by the Armed Forces have just been released to industry through the Office of Technical Services, U. S. Department of Commerce.

"Transformation Studies of Substitute Special Treatment Steels." Part I—Comparison of Transformation Diagrams. L. F. Spencer and R. H. Raring, Naval Research Laboratory. Nov. 1955. 17 pages. (Order PB 111783 from OTS, U. S. Department of Commerce, Washington 25, price 50 cents.) Two steels, enriched modifications of AISI 8727 and 87B27, which are being considered as substitutes for Ni-Cr STS, were compared on the basis of transformation characteristics and end-quench hardenability with a production sample of Ni-Cr STS. Isothermal transformation diagrams determined metallographically and continuous-cooling transformation diagrams determined dilatometrically indicate points of similarity and dissimilarity between the substitute steels and the standard Ni-Cr STS armor.

"X-Ray Diffraction Studies of the Bainite Transformation in Four Alloy Steels." L. S. Birks and R. T. Seal, Naval Research Laboratory. Oct. 1955. 13 pages. (Order PB 111771 from OTS, U. S. Department of Commerce, Washington 25, price 50 cents.) High-temperature x-ray diffraction techniques were used to study and compare the isothermal and continuous-cooling bainite transformations in four alloy steels. With short austenitizing time, the transformation to bainite was more rapid the lower the austenitizing temperature for a steel without boron, but a possible reverse effect was observed in a steel containing boron. For predicting continuous-cooling transformation from isothermal diagrams, a rapid, graphical solution of the Scheil approximation is described in which the isothermal diagram itself is used as one scale of a slide rule. Predicted and observed continuous - cooling transformations were compared for two of the steels and found to be in good agreement.

MTI BOOKLET

The Metal Treating Institute has recently published an illustrated 12-page booklet entitled *A Brief Statement of the Aims and Services of the Metal Treating Institute, the National Trade Association of Commercial Heat Treaters.* The booklet explains what the MTI is; lists its major activities since its founding in 1933; and describes some of the ways in which the Institute has served its members.

For further information circle No. 15

HEAT TREATMENT OF TOOL STEELS

Three new booklets entitled *Tool Steels for the Hot Extrusion Process; Tool Steels for Forging Operations;* and *Tool Steels for the Die Casting Process* are now available from the Crucible Steel Company of America, Pittsburgh, Pa.

Each of the booklets contains technical data concerning the properties, the heat treatment, and the application of Crucible tool steels in these various processes.

For your copies circle

Hot Extrusion No. 16

Forging Operations No. 17

Die Casting No. 18

CASTABLE REFRACTORIES

A new bulletin containing technical information on high temperature Alundum castable refractories has been published by Norton Company, Worcester, Mass. Alundum 33-I castable is a lightweight insulating castable recommended for protection against temperatures up to 3300°F.

Alundum 33-HD castable, a heavy duty castable made up primarily of pure aluminum oxide in dense grain form, is designed for the construction of high temperature furnaces where conditions are severe. Both these castables may be used to form intricate shapes quickly and easily.

For further information circle No. 19

ANHYDROUS AMMONIA

A new, 68-page technical data book on anhydrous ammonia and ammonia liquor has been prepared for industry by Nitrogen Division, Allied Chemical & Dye Corp.

The book fully describes anhydrous ammonia and ammonia liquor, listing their chemical and physical properties, specifications, handling and storage features, unloading methods, analytical procedures, and bibliography.

Graphic illustrations include data pertaining to viscosities, density, vapor pressures, boiling and freezing points, and other characteristics.

For further information circle No. 20

COMBUSTION SAFEGUARDS

A bulletin entitled "Selas Combustion Safeguards" published by the Selas Corporation of America, Dresher, Pa., describes the operation and construction of Selas Automatic Fire Checks which detect, localize and extinguish flashback in mixture supply line where a combustible mixture of fuel gas and air is distributed to heating equipment, and Selas Safety Blowouts which prevent flashback and relieve excessive flashback pressure in combustible mixture main supply piping.

These units are used in a manner analogous to that of fuses and circuit breakers in electrical supply lines.

For further information circle No. 21

THERMAL CONDUCTIVITY ANALYZER

A 12-page color catalog explains the principle, construction, operation and features of both the Hays Condu-Therm Analyzer and the Acratron Electronic Recorder. This analyzer can be used for determining amount of CO_2, H_2, He, CH_4, etc., and employs the thermal conductivity method of analysis.

The booklet contains a special section on gas sampling systems and how and why this analyzer is used.

For further information circle No. 22

HIGH VACUUM FURNACES

High Vacuum Equipment Corp., Hingham, Mass., a manufacturer of vacuum furnaces, has made an arrangement with Pacific Scientific Company, Los Angeles, Calif., to sell the latter's conventional furnaces in the East. Also, Pacific Scientific Company represents High Vacuum Equipment Corp. on the West Coast. This arrangement makes it possible for both companies to offer their equipment and services on a nationwide basis.

An 8-page, illustrated booklet published by the High Vacuum Equipment Corp. describes in detail their line of high vacuum furnaces for melting, heat treating, sintering, annealing, brazing, degassing, and purification of metals and alloys.

For further information circle No. 23

DEHYDRATION & PURIFICATION SYSTEMS

Air-Dry Corporation of America, designers and manufacturers of dehydration and purification systems for air and other gases, has a new brochure which contains information about the company and its products.

For further information circle No. 24

TRANSLATIONS AVAILABLE

Aware that much good literature of value and interest to heat treaters is being published abroad, METAL TREATING has made arrangements with a professional translator to advise us regularly of the availablity of English translations of outstanding magazine arti-

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cles, books, texts, etc., that would be of value to heat treaters.

The following translations are available from Henry Brutcher, P. O. Box 157, Altadena, California; all are illustrated and all have bibliographies. They may be secured by ordering directly from Mr. Brutcher.

No. 274—*The So-called Heterogeneity of Martensite;* by E. Maurer and G. Riedrich, translated from *Archiv Eisenhuttenwesen,* Vol. 4, 1930-31 ($4.40)

No. 491—*Influence of Heating Time and Grain Size Upon Austenite Transformation and Hardness Penetration;* by S. S. Shteinberg, V. V. Sklyuev and S. S. Nosyrova, translated from *Kachestvennaya Stal,* Vol. 5, 1937 ($1.80)

No. 652—*Hot Bath Quenching of Plain Carbon Steel;* by I. Feszczenko-Czopiwski and J. Banas, translated from *Prace Badawcze Huty Baildon,* Vol. 2, 1937 ($1.00)

No. 1409—*Influence of Initial Structure Upon Critical Rate of Cooling in the Hardening of Carbon Steel;* by W. Engel and N. Engel, translated from *Jernkontorets Annaler,* Vol. 117, 1933 ($4.25)

No. 1933—*Influence of Tempering Upon Quenching Stresses in Steel;* by H. Buhler and H. Buchholtz, translated from *Archiv Eisenhuttenwesen,* Vol. 8, 1934-35 ($3.60)

No. 1971—*On the Supercooling and Superheating of the Transformation Processes of Steel;* by R. Mitsche and A. Legat, translated from *Berg-und Huttenmannische Monatshefte,* Vol. 90, 1942 ($3.90)

No. 2083—*Method of Determining the Temperature Range of the Ac_1 Transformation in Steel;* by I. N. Golikov, translated from *Zavodskaya Laboratoriya,* Vol. 13, No. 12, 1947 ($2.65)

No. 2224—*Laboratory Determination of Critical Rate of Quenching;* by I. F. Afonskii, translated from *Zavodskaya Laboratoriya,* Vol. 14, No. 10, 1948 ($1.40)

No. 2363—*On the Causes of the Differences in the Effect of Alloy Elements Upon the Eutectoid Decomposition of Austenite and the Critical Rate of Quenching of Steel;* by M. E. Blanter, translated from *Doklady Akademii Nauk SSSR,* Vol. 67, 1949 ($2.55)

No. 2521—*On the Solution Mechanism of Carbides in Austenite;* by V. I. Arkharov and S. T. Kiselev, translated from *Izvestiya Akademii Nauk SSSR,* Otd. Tekh. Nauk, January 1949, No. 1. ($1.60)

No. 2687—*Carbide Phase During Tempering of Alloy Steels;* by S. Z. Bokshtein, translated from *Zhurnal Tekhnicheskoi Fiziki,* Vol. 19, 1949, No. 5 ($8.60)

No. 577—*Relationship Between Rate of Cooling, Rate of Transformation and Undercooling of Austenite, and Critical Rate of Quenching;* by S. Shteinberg, translated from *Metallurg,* Vol. 13, 1938 ($1.50)

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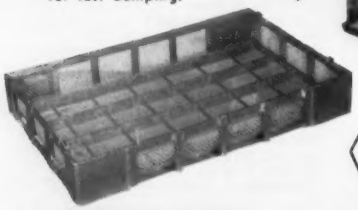

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